~~Keep the Date~~

The Electrochemical Society . . .

112th Meeting

BUFFALO
October 6–10, 1957

LOCAL COMMITTEE

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MAX E. BRETSCHGER

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Buffalo Program

THE ELECTROCHEMICAL SOCIETY

One Hundred and Twelfth Meeting

Sunday through Thursday

October 6, 7, 8, 9, and 10, 1957

CONDENSED TECHNICAL PROGRAM

Monday, October 7, 1957

Battery—(Abs. 1-10) 9:30 A.M.-12:00 M.; 2:00-5:00 P.M. (Maple Leaf Room)

Corrosion—Electrodeposition (Abs. 56-64) 9:45 A.M.-12:20 P.M.; 2:00-5:15 P.M. (Los Angeles Room)

Electronics—Semiconductors 9:30 A.M.-12:00 M.; 2:00-5:00 P.M. (Ballroom)

Electro-Organic (Abs. 79-85) 10:00 A.M.-12:00 M.; 2:00-3:30 P.M.; 3:30-5:00 P.M. Round Table (Empire State Room)

Electrothermics and Metallurgy (Abs. 98-100) 2:00-4:00 P.M. (New York Room)

Tuesday, October 8, 1957

Battery (Abs. 11-22) 9:00 A.M.-12:00 M.; 2:00-5:00 P.M. (Maple Leaf Room)

Corrosion (Abs. 29-39) 9:00-11:45 A.M.; 2:00-5:00 P.M. (Sheraton Hotel)

Electrodeposition (Abs. 65-73) 9:30 A.M.-12:00 M.; 2:00-4:00 P.M. (Buffalo Room)

Electronics—Semiconductors 9:30 A.M.-12:00 M.; 2:00-5:00 P.M. (Ballroom)

Electro-Organic (Abs. 86-95) 9:00-11:30 A.M.; 2:00-4:30 P.M. (Los Angeles Room)

Electrothermics and Metallurgy (Abs. 101-104) 9:15-11:45 A.M. (Georgian Room)

Wednesday, October 9, 1957

Battery (Abs. 23-28) 9:00 A.M.-12:00 M. (Maple Leaf Room)
Corrosion (Abs. 40-44) 9:00-11:30 A.M. (Georgian Room)
Electrodeposition (Abs. 74-78) 9:00 A.M.-12:15 P.M. (Buffalo Room)
Electronics—Semiconductors 9:30 A.M.-12:00 M. (Ballroom)
Electrothermics and Metallurgy (Abs. 105-108) 9:30-11:30 A.M. (Empire State Room)

Thursday, October 10, 1957

Battery 9:00 A.M.-12:00 M. Round Table (Ballroom)
Corrosion (Abs. 45-55) 9:00-11:45 A.M.; 2:00-5:00 P.M. (Georgian Room)
Electro-Organic (Abs. 96-97) 9:00-10:00 A.M.; 10:00 A.M.-12:00 M. Round Table (Empire State Room)

GENERAL INFORMATION

Convention Headquarters will be at the Hotel Statler, Delaware Ave. at Niagara Square, Buffalo, N. Y.

Rates per day for rooms (with bath) will be: single room $6.00 through $16.00; suites for one or two $24.00 through $37.00.

Requests for room reservations at the Headquarters Hotel should be mailed to the Front Office Manager, Hotel Statler, Delaware Ave. at Niagara Square, Buffalo 5, N. Y. *Be sure* to state your intention to attend The Electrochemical Society meeting.

Other hotels within a few blocks of the Headquarters Hotel and their minimum rates are:

Lafayette, Washington & Clinton Sts.,—single $5.00; double $9.00; twin-bed $10.00; suite $22.00.

Buffalo Hotel, Washington & Swan Sts.,—single $6.50 through $7.00; double-bed room $9.50 through $10.00; twin-bed room $11.00 through $12.00; suites for one or two $17.00 and $21.00. A suite for three persons is available at $27.00.

Sheraton Hotel, 75 Delaware Ave.—single $6.85 through $10.50; double-bed $9.35; twin-bed $10.35 through $14.00; suite $16.00 through $30.70; (free parking area).

Stuyvesant Hotel, 245 Elmwood Ave.—single $7.00 through $12.00;

double-bed $10.00 through $14.00; twin-bed $13.00 through $20.00; suite $18.00 through $30.00; (free parking area).

There are numerous motels in or near Buffalo, but considerably farther from the Convention Headquarters. Three of these are as follows:

Mohawk Manor, 1640 Main St. (From the west, Route 20, from east or west, Route 3)—single $6.50 through $7.50; double-bed $10.00; twin-bed $10.50 through $12.50.

Towne House, 24 High St. at Main (Route 5)—single $7.00, $8.00, and $9.00; twin-bed $12.00, $14.00, and $16.00; at least two persons may be accommodated in each room of the Towne House, as each and every room has double beds.

Kenton Manor, 2075 Sheridan Dr. (Route 324)—single $7.00; double-bed $8.50; twin-bed $9.50; also room with a single and double-bed $10.50 or room with two double beds to accommodate possible four persons $12.50 and $16.00.

Accommodations may also be had at the local Y.M.C.A.

Requests for room reservations should include mention of The Electrochemical Society.

The Office of the Secretary will be in the Hartford Room on the Mezzanine Floor.

All technical sessions will be held on the Mezzanine Floor; the Tuesday sessions and luncheon of the Corrosion Division will be held at the Sheraton Hotel, 715 Delaware Ave., a 15-minute walk from the Hotel Statler.

Ladies' Headquarters will be in the Detroit Room on the Mezzanine Floor. For details, *see* Ladies' Program.

REGISTRATION

The registration desk will be in the lounge on the Mezzanine Floor. Following is the registration schedule:

Sunday, Oct. 6—3:00 P.M. to 9:00 P.M.

Monday, Oct. 7—8:00 A.M. to 5:00 P.M.

Tuesday, Oct. 8—8:30 A.M. to 5:00 P.M.

Wednesday, Oct. 9—8:30 A.M. to 5:00 P.M.

Thursday, Oct. 10—8:30 A.M. to 12:00 M.

Registration fees are:

Members	$ 7.00
Ladies	5.00
Nonmembers	13.00
Nonmembers (one day only)	5.00
Students	2.00

INFORMATION ABOUT BUFFALO AND NIAGARA FALLS

Buffalo, in the heart of the world-famous Niagara Region and at the gateway to Canada, is the hub of a great concentration of industrial and commercial activity. One of America's great inland water ports, Buffalo is now rapidly preparing for the opening of the St. Lawrence Seaway in 1959 which will make it a world port. The largest grain milling and distribution center in the world, Buffalo stands astride the busy terminals of 11 major railroads, and at the western terminus of the State Barge Canal and the New York State Thruway. It is the shipping or exchange point for the huge flow of traffic between East and West and to and from Canada.

Buffalo is the second largest city in New York State in population, second only to New York City, and the 15th in size in the nation. As of January 1, 1957 the population was 604,000, and total population in the Buffalo-Niagara Metropolitan area now stands at 1,223,000.

There is a great diversity of industry—both large and small manufacturers—in the Metropolitan Buffalo area. Among the leading industries are: steel works and rolling mills, chemicals, petroleum products, machinery, feed, flour, grain milling, rubber and nonferrous metal products, clothing, plastics, drugs, and furniture.

The University of Buffalo, with a total enrollment of approximately 11,000 in the student body, embraces a wide spectrum of education including Arts and Sciences, Business Administration, Chronic Disease Institute, Dentistry, General and Technical Studies, Engineering, Education, Graduate Arts and Sciences, Law, Medical, Millard Fillmore College (night school), Nursing, Phar-

macy, and Social Work. The Chancellor is Dr. Clifford C. Furnas.

Buffalo is also a city abounding in recreational and cultural values and beauty. It has a $3,000,000 zoo and 10 public parks containing over 3,000 acres of land. The fine traditions of American culture are expressed by Buffalo's Historical Museum, The Museum of Natural Sciences, The Albright Art Gallery, and other centers. The Albright Art Gallery is well known in international art circles for its collection of old masters and modern paintings and sculptures. Kleinhans Music Hall is another point of interest in Buffalo, and is the home of the renowned Buffalo Philharmonic Orchestra.

The Statler-Hilton Hotel is located on historic Niagara Square in the heart of the downtown area, and most convenient to business, shopping, and theatrical districts.

For those planning to participate in the "Niagara Falls Day" activities on Wednesday, there is a real treat in store. Niagara Falls is 25 miles north of Buffalo. In addition to its world renowned scenic splendor, it is also the center of one of the largest electrochemical and electrometallurgical production areas in the world. Some of the more important products are: chlorine, caustic soda and caustic potash, ferroalloys, carbon and graphite products, abrasives, resins and chlorinated organics, metallic sodium, paper and paper products, and lumber and millwork. Bell Aircraft's rocket and guided missiles plant is also situated here. Niagara University is located at Niagara Falls.

Climaxing "Niagara Falls Day" will be a cocktail and dinner party in the beautiful Rainbow Room of the Sheraton-Brock Hotel in Niagara Falls, Canada.

SYMPOSIA AND ROUND TABLES

The Battery Division has scheduled symposia on: Lead Oxides—Their Composition, Structure, and Importance in Storage Batteries; Importance of Design Factors on Storage Battery Performance; Unconventional Electrochemical Systems

for Batteries; and a Round-Table Discussion of Fuel Cells.

The Corrosion Division and **Electrodeposition Division** have scheduled a joint symposium on Corrosion of Electrodeposited Metals.

The Electrodeposition Division has scheduled symposia on: Growth of Electrodeposits; and Electrolytic Metal Powders.

The Electronics Division—Semiconductor Group has scheduled symposia on: Elemental Semiconductors; Semiconductor Compounds and Alloys; Surface Phenomenon; Diffusion and Process Technology.

The Electro-Organic Division has scheduled symposia on: Arc Electrolysis; Cathodic Reduction of Organic Compounds; Polarography; a Round-Table Discussion on the Industrial Future of Electro-Organic Chemistry; a second Round-Table Discussion on the Application of Polarographic Techniques in the Pharmaceutical Field.

The Electrothermics and Metallurgy Division has scheduled a symposium on Ferroalloys and Slags.

GENERAL FUNCTIONS

Symposia Chairmen Breakfasts

On **Monday, Tuesday, Wednesday,** and **Thursday, October** 7, 8, 9, and 10, at 7:45 A.M., special breakfasts for all symposia chairmen will be held, on Monday and Wednesday in the St. Louis Room, on Tuesday in the Club Room, and on Thursday in the Detroit Room.

Monday Evening

Although no Society events are scheduled, the local committee will be glad to provide information regarding available dining and entertainment in Buffalo and assist in obtaining reservations and transportation.

Tuesday Palladium Medal Banquet

A reception and dinner in honor of the Palladium Medalist, the late Karl Friedrich Bonhoeffer, will be held at 6:30 P.M. in the Foyer of the Ballroom, Lobby floor. Dr. Bonhoeffer was head of the Max Planck Institute for Physical Chemistry. A reception will be held from 6:30 to

7:30 P.M. followed by dinner at 7:30 P.M. in the Ballroom.

Wednesday Evening Supper at Niagara Falls, Ontario

On Wednesday, October 9, an informal party will be held in the Rainbow Salon of the Sheraton Brock Hotel, Niagara Falls, Ont. The Rainbow Salon is located on the 10th floor of the hotel, and overlooks the Falls of Niagara. Cocktails will be served from 6:00 to 7:00 P.M.; a buffet supper will be served at 7:00 P.M. Illumination of the falls is scheduled for 8:30 P.M. Daylight Saving Time. Busses will depart at 9:30 P.M. for the return trip to Buffalo.

All plant visits in the Niagara Falls area are scheduled for Wednesday afternoon, and all these trips will converge at the Sheraton Brock Hotel in time for the party. The Ladies Scenic Tour of Niagara is also scheduled for Wednesday, and this trip will arrive at the Sheraton Brock in time for the party. For the convenience of members and guests who wish to attend the party at the Sheraton Brock and who are unable to leave sooner, a shuttle bus will leave the Delaware Ave. entrance of the Statler Hotel, Buffalo, at 5:00 P.M.

For the return trip to Buffalo, all busses will leave the Sheraton Brock promptly at 9:30 P.M., and the estimated time of arrival at the Hotel Statler is 10:30 P.M.

Tickets for the Brock Party and for transportation must be purchased at time of registration.

IMPORTANT: The Sheraton Brock Hotel is in *Canada*. Citizens of countries other than the U. S. and Canada should carry their passports and their visas for return entry to the United States. The U. S. Immigration Office advises that for naturalized citizens the law does not require that they carry their papers, but it is preferable since it simplifies and expedites crossings.

PLANT AND LABORATORY TOURS

Because of the number of trips which have been arranged for this meeting, registrants should purchase

tickets early to insure that they can go on the trips of their choice. The maximum number for each tour is 90 persons. On trips into Canada, citizens of countries other than the United States and Canada must have passports or other means to insure re-entry into the United States. All busses leave from the Delaware Avenue entrance of the Hotel Statler.

Tuesday, October 8, 1:30 P. M.

Choice of two tours:

Trip No. 1—Cornell Aeronautical Laboratory, Inc., Buffalo, New York. —Trip limited to United States citizens. This laboratory, now administered by Cornell University, is the former research laboratory of Curtiss Wright Corp. It engages in contract research for the Air Force and others, particularly on aeronautical subjects. Visitors will be shown the big wind tunnel and also the supersonic and hypersonic tunnels and control rooms for these; also the high altitude chamber, the model shop, the flutter-study model plane, and other nonclassified areas. Collision impact safety studies will be illustrated in motion pictures. Laboratory personnel will explain various angles. Estimated time of return to hotel is 4:15 P.M. Bus fare $1.00. Chartered busses will leave the Delaware Ave. entrance of the Hotel Statler at 1:30 P.M.

Trip No. 2—Carborundum Metals Division of the Carborundum Co., Akron, N. Y. (20 miles east of Buffalo)—This modern plant is the pioneering commercial producer of zirconium and hafnium metals in sponge and ingot form of high purity suitable for nuclear reactor and corrosion-resisting uses. Visitors will see the entire process (recently declassified), starting with crude zirconium chloride which is dissolved, put through a liquid-liquid extraction process to separate hafnium from the zirconium, and then reconverted to chloride which is reduced to sponge in a modified Kroll process. Ingot melting facilities will also be shown, together with the modern research, control, and spectrographic laboratories. Chartered busses will leave the Delaware Ave. entrance of the Hotel Statler at 1:30 P.M. Bus

fare $1.50. Estimated time of return to the hotel is 5:00 P.M.

Wednesday, October 9, 1:30 P. M.
(Niagara Falls Day)

Choice of three simultaneous tours, each of which will terminate at the Sheraton Brock Hotel in Niagara Falls, Ontario, at approximately 5:30 P.M. for cocktails and dinner, followed by return to Buffalo past the illuminated falls and along the Canadian shore, re-entering United States via the Peace Bridge at Buffalo. Chartered busses will leave the Delaware Ave. entrance of the Hotel Statler promptly at 1:30 P.M. Bus fare for each tour is $2.50.

Trip No. 3—International Nickel Co., Port Colborne, Ont.—Visit limited to United States or Canadian citizens. This plant receives crushed sulfide concentrates from the mines in Northern Ontario. Visitors will see these fired in reverberatory furnaces, anode forming, and refining operations conducted in the largest electroplating room in the world, covering some 12 acres. Both nickel and cobalt are produced in the form of sheet and shot. Black and green oxides are also produced for the ceramic trade and for the manufacture of ferrites for the electronics industry. Chlorination and other chemical processing steps of interest are involved.

Trip No. 4—Metals Research Laboratories, Electro Metallurgical Co. and Hooker Electrochemical Co., Niagara Falls, N. Y.—The Niagara Falls Metals Research Laboratories handle all metallurgical research for the Union Carbide Corp., including Electro Metallurgical Co. and Haynes Stellite Co. Divisions.

This modern, newly expanded laboratory entirely devoted to metallurgical research is one of the most comprehensive laboratories of this type in the United States. Complete facilities are available for development of metals and alloys, including furnaces, forging hammers, rolling mills, x-ray diffraction, metallographic equipment, physical testing, welding, and chemical processing equipment.

The group will then be taken to the chlorine-caustic soda plant of

Hooker Electrochemical Co., where they will visit the cell rooms with Hooker Type S and Type S-3A cells, chlorine liquefication and caustic soda evaporation. This is the home plant of the Hooker Type cell which is used in 40 plants in the United States and other countries.

Trip No. 5—North American Cyanamid, Ltd., Niagara Falls, Ont., and Ontario Hydro Power Plant, Queenston, Ont.—Open to all. Our party will cross into Canada on the Peace Bridge and drive along the scenic Niagara River to the North American Cyanamid plant. Here they will see the preparation of raw materials (lime and coke) followed by furnacing in 21,000 kw furnaces to form calcium carbide, then the crushing and milling of the carbide and its nitrification to form cyanamid, and finally the milling of this into finished product. A large liquid air plant furnishes the nitrogen for the process. This is the 50th Anniversary of the company on its present site.

Next the group will be taken to the new Sir Adam Beck Generating Station No. 2 of the Ontario Hydro Commission, opened August 30, 1954, with a capacity of 1,828,000 hp at a cost of nearly $344,000,000. Just beyond is Sir Adam Beck Station No. 1 opened December 29, 1921.

Water for the new station enters two intake structures 2 miles above the Falls, passing through twin 5½ mile tunnels, diving 330 ft under the City of Niagara Falls and entering a 2½ mile open cut canal. The tunnels have a diameter of 45 ft and their construction required removal of over 4 million cubic yards of rock. In building the canal and forebay, more than 8 million cubic yards of rock were removed.

LADIES PROGRAM

Ladies' Headquarters will be in the Club Room on Sunday, Detroit Room on Monday, Tuesday, and Wednesday, and in the Boston Room on Thursday. A member of the Ladies' Committee will be in the Ladies' Headquarters on Sunday from 3:00 to 9:00 P.M. to welcome and assist the ladies in every way.

The temperature in Buffalo during early October is usually in the 50°-70° range. Buffalo is a windy city.

Monday morning, October 7—A get-together period with coffee will be held in the Ladies' Headquarters (Detroit Room) starting at 9:30 A.M. (complimentary).

Monday afternoon, October 7—A complimentary luncheon will be given at the Park Lane Hotel starting at 1:00 P.M. After the luncheon, the ladies will hear a talk by a member of the Jane Keeler Studio Theatre Group. The ladies will leave from the Delaware Ave entrance of the Hotel Statler at 12:30 P.M. and will return about 3:00 P.M. The remainder of the afternoon will be open for shopping or individual sight-seeing. (Tickets complimentary).

Monday evening, October 7—Although no Society events are scheduled, the Local Committee will be glad to provide information about available dining and entertainment in Buffalo and assist in obtaining reservations and transportation.

Tuesday morning and afternoon, October 8—Coffee will be served in Ladies Headquarters (Detroit Room) at 9:30 A.M. (complimentary). The ladies are invited to luncheon and bridge at the beautiful Buffalo Country Club on the Onondaga Escarpment (with the compliments of the Buffalo Electrochemical Co., Division of Food Machinery Corp.). For ladies not interested in bridge, the Committee will provide transportation after lunch to other places of interest. Chartered bus will be boarded at the Delaware Ave entrance of the Hotel Statler at 12.00 M. The bus will return to the hotel about 4:00 P.M. (tickets complimentary).

Tuesday evening, October 8—The ladies are invited to attend the Palladium Medal Reception and Banquet at 6:30 P.M. (tickets should be purchased at time of registration.)

Wednesday morning, afternoon, and evening, October 9—Niagara Falls Day—Coffee will be served in Ladies' Headquarters (Detroit Room) at 9:30 A.M. (complimentary).

At 11:00 A.M. ladies will meet at the Delaware Ave. entrance of the

Hotel Statler, to board the bus for a tour of the Niagara Frontier. Luncheon will be served enroute at the Niagara Falls Country Club at 1:15 P.M. In the afternoon, historic Old Fort Niagara, at the mouth of the Niagara River, will be visited. The party will then cross into Canada passing through Queenston and Victoria Parks. The ladies will then join the members at the Hotel Sheraton Brock, at Niagara Falls, Ont., where cocktails and a buffet supper will be served in the Rainbow Salon; busses will leave the Sheraton Brock promptly at 9:30 P.M. and the return trip will be made along the Canadian side of the river and over the Peace Bridge. Estimated time of arrival at the Statler Hotel is 10:30 P.M. (tickets for this trip should be purchased at time of registration.)

IMPORTANT—Citizens of countries *other than* the United States and Canada must carry passports and visas.

For *naturalized* citizens, the Immigration Office advises that the law does not require evidence of naturalization, but that having Naturalization Papers is preferable in that it simplifies and expedites crossing.

Thursday morning, October 10—Coffee will be served at 9:30 A.M. in the Ladies' Headquarters (Boston Room) (complimentary). This morning and afternoon have been left open for shopping and informal tours. The Hotel Statler is within walking distance of the shopping and theater districts.

LUNCHEONS AND BUSINESS MEETINGS OF DIVISIONS

Battery Division Luncheon and Business Meeting, Tuesday, October 8, at 12:30 P. M. in the Maple Leaf Room.

Corrosion Division Luncheon and Business Meeting, Tuesday, October 8, at 12:30 P. M. at the Sheraton Hotel, 715 Delaware Ave., a 15-minute walk from the Hotel Statler.

Electrodeposition Division Business Meeting, Tuesday, October 8, at 4:00 P. M. in the Buffalo Room.

Electro-Organic Division Luncheon and Business Meeting, Monday, October 7, at 12:30 P. M. in the New York Room.

MEETING ROOM SCHEDULES

Meeting	Monday		Tuesday		Wednesday		Thursday	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Battery	A	A	A	A	A		B	
Corrosion			C	C	D		D	D
Corrosion—Electrodeposition	E	E						
Electrodeposition			F	F	F			
Electronics—Semiconductors	B	B	B	B	B			
Electro-Organic	G	G	E	E			G	
Electrothermics and Metallurgy		H	D		G			

A = Maple Leaf Room
B = Ballroom
C = Sheraton Hotel, 715 Delaware Ave.
D = Georgian Room
E = Los Angeles Room
F = Buffalo Room
G = Empire State Room
H = New York Room

BOARD AND COMMITTEE MEETINGS

Sunday, October 6, 2:00 P. M.—Meeting of the Board of Directors in the St. Louis Room.

Monday, October 7, 5:00 P. M.—Meeting of the Council of Local Sections in the Grover Cleveland Room.

Monday, October 7, 5:00 P. M.—Meeting of the Editorial Staff of the JOURNAL in the Hartford Room.

Tuesday, October 8, 5:00 P. M.—Meeting of the Membership Committee in the Grover Cleveland Room.

Thursday, October 10, 12:00 M.—Meeting of General Chairmen of Future Meetings in the Hartford Room.

COST OF VARIOUS FUNCTIONS

(other than registration)

Symposia Chairmen Breakfasts	$2.50
Division Luncheons	3.00
Tuesday Reception and Banquet	
Gentlemen	7.00
Ladies	4.00
Wednesday Evening Party at Sheraton-Brock	
Gentlemen	5.50
Ladies	4.00
Trip No. 1 to Cornell Aeronautical Laboratory (transportation)	1.00
Trip No. 2 to Carborundum Metals (transportation)	1.50
Trip No. 3 to International Nickel (transportation)	2.50
Trip No. 4 to Metals Research Lab and Hooker Electrochemical (transportation)	2.50
Trip No. 5 to North American Cyanamid and Sir Adam Beck Power Station (transportation)	2.50
Trip No. 6 direct to Sheraton-Brock Hotel (transportation only)	1.75
Ladies' Functions:	
Trip No. L-1 to Park Lane, luncheon and transportation, complimentary	
Trip No. L-2 to Buffalo Country Club, Luncheon and Transportation, complimentary	
Trip No. L-3 all-day tour of Niagara Frontier (including luncheon at the Niagara Falls Country Club, but not including tickets for dinner at the Sheraton-Brock)	4.00

JOURNALS

Copies of the July, August, September, and October issues of the JOURNAL of The Electrochemical Society will be available at the registration desk. The price of a single copy of the JOURNAL is $1.25 to members and $1.75 to nonmembers.

EXTENDED ABSTRACTS

The Battery Division is making available an extended abstract booklet containing 1000-word abstracts of most of the papers presented at the Division's Buffalo symposia. Copies of the booklet will be on sale for $2.00 at the registration desk.

DISCUSSION

No recordings will be made of oral discussions. Those contributing to the discussion of a paper and desiring their remarks to be published will be supplied by the symposium chairman with a printed form on which any discussion may be written. These forms should be given to the Secretary-Treasurer of the Division or to the Managing Editor of the JOURNAL after the session; they can be mailed to the Managing Editor of the JOURNAL, 1860 Broadway, New York 23, N. Y. The discussion will then be referred to the author for reply. Publication of the discussion and the comments of the author depends on publication of the article in the JOURNAL.

Written discussion should be submitted within two months following publication of the article in the JOURNAL. A Discussion Section is published semiannually in the JOURNAL.

EMPLOYMENT POSTERS

Companies which desire to recruit employees at the Buffalo Meeting will have posters to this effect on a bulletin board near the registration desk.

Technical Program

Monday, October 7, 1957

9:00 A.M.—Formal Opening of the 112th Meeting with Introduction by General Chairman Robert B. MacMullin and Response by President Norman Hackerman (Ballroom).

NOTE

In the Index to Authors, the abstract number is used. Address of author(s) is included with the abstract.

BATTERY

Monday, October 7, 1957

Lead Oxides—Their Composition, Structure, and Importance in Storage Batteries
with E. Willihnganz presiding
(MAPLE LEAF ROOM)

9:30 A.M.—"The Anodic Oxides on Lead" by Jeanne Burbank (Abstract No. 1)

10:10 A.M.—"The Electrochemical Properties of the PbO_2 and the Anodic Corrosion of Lead and Lead Alloys" by Paul Ruetschi (Abstract No. 2)

10:50 A.M.—"The Correction of X-Ray Diffraction Powder Photographs for Highly Absorbing Samples" by P. E. Jensen and E. J. Ritchie (Abstract No. 3)

11:30 A.M.—"The Unit Cell of Yellow Litharge" by P. E. Jensen and E. J. Ritchie (Abstract No. 4)

Battery (cont'd)

Monday, October 7, 1957

Importance of Design Factors on Storage Battery Performance
with E. J. Ritchie presiding
(MAPLE LEAF ROOM)

2:00 P.M.—"Changes in Positive Active Material Density during Various Conditions of Service" by J. F. Dittmann and J. F. Sams (Abstract No. 5)

2:30 P.M.—"The Action of Silver and Cobalt at the Positive Plate of the Lead-Acid Battery" by J. J. Lander (Abstract No. 6)

3:00 P.M.—"Influence of Positive Grid Alloy and Element Design on Battery Performance" by H. Stoertz (Abstract No. 7)

3:30 P.M.—"Design and Quality Control in the Battery Industry through Microscopy" by A. C. Simon and E. L. Jones (Abstract No. 8)

4:00 P.M.—"Designing for Quality" by H. J. Strauss (Abstract No. 9)

4:30 P.M.—"Design Factors for Nickel-Cadmium Batteries" by Arthur Fleischer, R. E. Rockey, and G. B. Ellis
(Abstract No. 10)

Battery (cont'd)
Tuesday, October 8, 1957
General Session
with W. S. Herbert presiding
(MAPLE LEAF ROOM)

9:00 A.M.—"Improvement in Negative Plate Performance" by Arthur Fleischer
(Abstract No. 11)

9:30 A.M.—"Cinemicrography of the Freezing Process in Lead-Antimony Grid Alloys" by A. C. Simon and E. L. Jones
(Abstract No. 12)

10:00 A.M.—"Measurement of the Internal Resistance of Standard Cells" by G. D. Vincent
(Abstract No. 13)

10:30 A.M.—"A New Approach to Resistance Measurements of Dry Cells" by R. J. Brodd
(Abstract No. 14)

11:00 A.M.—"Formation of Manganese (II) Ion in the Discharge of the Manganese Dioxide Electrode, II. Effect of Volume and *p*H of Electrolyte" by W. C. Vosburgh, M. J. Pribble, Akiya Kozawa, and Ahmed Sam
(Abstract No. 15)

11:30 A.M.—"The Relation of the Conditions of Electrodeposition of Manganese Dioxide to the Discharge Characteristics" by Akiya Kozawa and W. C. Vosburgh (Abstract No. 16)

12:30 P.M.—Battery Division Luncheon in the Maple Leaf Room.

Battery (cont'd)
Tuesday, October 8, 1957
Unconventional Electrochemical Systems for Batteries
with C. W. Morehouse presiding
(MAPLE LEAF ROOM)

2:00 P.M.—"Studies of the Vapor Pressure and the Density of Electrolytes for Dry Cells" by Kumazo Sasaki
(Abstract No. 17)

2:30 P.M.—"A Magnesium Sea-Water Battery" by J. J. Shotwell and R. C. Kirk
(Abstract No. 18)

3:00 P.M.—"Ammonia Vapor-Activated Reserve Batteries" by H. S. Gleason, J. M. Freund, L. J. Minnick, and W. F. Meyers (Abstract No. 19)

3:30 P.M.—"A Unique Dry Battery" by H. B. Reed, Jr., and M. B. Goldberg (Abstract No. 20)

4:00 P.M.—"Indium as an Anode Material" by T. L. Boswell (Abstract No. 21)

4:30 P.M.—"Halogen-Activated Solid Electrolyte Cell" by J. L. Weininger (Abstract No. 22)

Battery (cont'd)

Wednesday, October 9, 1957

Unconventional Electrochemical Systems for Batteries
Organic Cathodes
with U. B. Thomas presiding
(MAPLE LEAF ROOM)

9:00 A.M.—"An Investigation of Some New Cathode Depolarizer Materials" by A. B. Tripler, Jr., and L. D. McGraw (Abstract No. 23)

9:30 A.M.—"Investigations of Electrochemical Characteristics of Organic Compounds, I. Aromatic Nitro Compounds" by R. Glicksman and C. K. Morehouse (Abstract No. 24)

10:00 A.M.—"Nitro Aromatic-Magnesium Dry Cells" by C. K. Morehouse and R. Glicksman (Abstract No. 25)

10:30 A.M.—"Investigations of Electrochemical Characteristics of Organic Compounds, II. Aromatic Nitroso Compounds" by R. Glicksman and C. K. Morehouse (Abstract No. 26)

11:00 A.M.—"Nitroso Aromatic-Magnesium Dry Cells" by C. K. Morehouse and R. Glicksman (Abstract No. 27)

11:30 A.M.—"N-Halogen Reserve Batteries" by G. S. Lozier, L. H. Cutler, and C. K. Morehouse (Abstract No. 28)

Battery (cont'd)

Thursday, October 10, 1957

Round-Table Discussion of Fuel Cells
with G. W. Heise presiding
(BALLROOM)

9:00 A.M.-12:00 M.—This discussion will be led by a number of

panel members and will cover basic aspects of fuel cell electrochemistry, cells with aqueous electrolytes, cells with fused salt electrolytes, and fuel sources.

CORROSION

Tuesday, October 8, 1957
with C. V. King presiding
(SHERATON HOTEL)

9:00 A.M.—"The Germanium-Water-Oxygen System: Kinetics of the Dissolution Process" by W. W. Harvey and H. C. Gatos (Abstract No. 29)

9:30 A.M.—"Oxidation of Copper Single Crystals in Oxygen-Saturated Water at Room Temperature" by Jerome Kruger (Abstract No. 30)

10:15 A.M.—"Metal-Water Reactions, IV. Kinetics of the Reaction between Calcium and Water Vapor" by H. J. Svec and Charles Apel (Abstract No. 31)

10:45 A.M.—"Metal-Water Reactions, V. Kinetics of the Reaction between Magnesium and Water Vapor" by H. J. Svec and D. S. Gibbs (Abstract No. 32)

11:15 A.M.—"Electrochemical Polarization, III. Further Aspects of the Shape of Polarization Curves" by Milton Stern (Abstract No. 33)

12:30 P.M.—Corrosion Division Luncheon and Business Meeting at the Sheraton Hotel.

Corrosion (cont'd)
Tuesday, October 8, 1957
with C. V. King presiding
(SHERATON HOTEL)

2:00 P.M.—"Electrochemistry of Magnesium" by G. R. Hoey and M. Cohen (Abstract No. 34)

2:30 P.M.—"Use of High Purity Aluminum and Its Alloys in Controlling the Corrosion of Magnesium Alloys, I. The Galvanic Compatibility of Aluminum Alloys with Magnesium Alloys" by M. R. Bothwell (Abstract No. 35)

3:00 P.M.—"Use of High Purity Aluminum and Its Alloys in

Controlling the Corrosion of Magnesium Alloys, II. The Protection of Magnesium Alloys by Aluminum" by M. R. Bothwell (Abstract No. 36)

3:30 P.M.—"Reaction of Aluminum and Carbon Tetrachloride, I." by J. D. Minford, M. H. Brown, and R. H. Brown (Abstract No. 37)

4:00 P.M.—"Reaction of Aluminum and Carbon Tetrachloride, II" by R. H. Brown, E. H. Cook, M. H. Brown, and J. D. Minford (Abstract No. 38)

4:30 P.M.—"Accelerated Corrosion in Aluminum-Silver Alloys" by H. H. Stadelmaier and E. M. Whitener (Abstract No. 39)

Corrosion (cont'd)

Wednesday, October 9, 1957

with M. A. Streicher presiding

(GEORGIAN ROOM)

9:00 A.M.—"Room Temperature Tarnishing of Silver in Bromine and Iodine" by J. L. Weininger (Abstract No. 40)

9:30 A.M.—"Effect of Steel, Passivating Solution, and Corrosive Media Variations on the Electrochemical Method of Detecting Hydrogen Diffusion through Steel" by T. J. Butler (Abstract No. 41)

10:00 A.M.—"Cathodic Reduction of Oxide Films on Iron, II. Determination of α-Fe_2O_3 and Fe_3O_4." by K. H. Buob, A. F. Beck, and M. Cohen (Abstract No. 42)

10:30 A.M.—"Chemical Factors Affecting Stress Corrosion Cracking of 18-8 Stainless Steels" by H. H. Uhlig and John Lincoln, Jr. (Abstract No. 43)

11:00 A.M.—"The Effect of Gamma Irradiation on the Potential Behavior of Platinum and Stainless Steel Electrodes" by W. E. Clark (Abstract No. 44)

Corrosion (cont'd)

Thursday, October 10, 1957

with J. E. Draley presiding

(GEORGIAN ROOM)

9:00 A.M.—"The Diffusion of Oxygen in Zirconium" by J. P. Pemsler (Abstract No. 45)

9:30 A.M.—"Formation Fields and Current Efficiencies in the Anodic Oxidation of Zirconium: A Direct Comparison of High Potential Formation Fields with Those Derived from Low Potential Charging Curves" by G. B. Adams, Jr., T. S. Lee, and Pierre Van Rysselberghe (Abstract No. 46)

10:15 A.M.—"The Reaction of Zirconium with Water Vapor at Subatmospheric Pressures" by M. W. Mallett, W. M. Albrecht, and R. E. Bennett (Abstract No. 47)

10:45 A.M.—"Reaction of Hydrogen with Preoxidized Zircaloy-2 at 300°-400°C" by E. A. Gulbransen and K. F. Andrew (Abstract No. 48)

11:15 A.M.—"The Effect of Pre-Oxidation in Oxygen on the Steam Corrosion Behavior of Zircaloy-2" by D. E. Thomas and S. Kass (Abstract No. 49)

Corrosion (cont'd)
Thursday, October 10, 1957
with J. E. Draley presiding
(GEORGIAN ROOM)

2:00 P.M.—"Electrolytic Etching of Dense Tantalum" by A. L. Jenny and R. A. Ruscetta (Abstract No. 50)

2:30 P.M.—"Metallographic Manifestations of the Air Oxidation of Tantalum at 750°C" by Robert Bakish (Abstract No. 51)

3:00 P.M.—"Nucleation of Crystalline Ta_2O_5 during Field Crystallization" by D. A. Vermilyea (Abstract No. 52)

3:30 P.M.—"Ionic Conductivity of Anodic Films at High Field Strengths: Transient Behavior" by D. A. Vermilyea (Abstract No. 53)

4:00 P.M.—"Annealing Anodic Ta_2O_5 Films: Changes in Dissolution Behavior and X-Ray Scattering" by D. A. Vermilyea (Abstract No. 54)

4:30 P.M.—"Effect of Ultraviolet Irradiation on the Growth of Anodic Ta_2O_5 Films" by D. A. Vermilyea (Abstract No. 55)

CORROSION—ELECTRODEPOSITION

Joint Symposium

Monday, October 7, 1957

Corrosion of Electrodeposited Metals with F. A. Lowenheim presiding

(LOS ANGELES ROOM)

9:45 A.M.—"The Mechanism of Corrosion of Copper-Nickel-Chromium Coatings" by H. J. Read (Abstract No. 56)

10:30 A.M.—"Double Nickel Coatings" by B. B. Knapp and R. J. McKay (Abstract No. 57)

11:10 A.M.—"Effects of Acoustical Waves on the Electrodeposition of Chromium" by Joseph Dereska, Ernest Yeager, and Frank Hovorka (Abstract No. 58)

11:50 A.M.—"Electrodeposition of Chromium Alloys—A Literature Review" by Charles Levy (Abstract No. 59)

Corrosion-Electrodeposition Joint Symposium (cont'd)

Monday, October 7, 1957

Corrosion of Electrodeposited Metals with H. R. Copson presiding

(LOS ANGELES ROOM)

2:00 P.M.—"The Protective Value of Tin-Nickel Alloy Deposits on Steel" by F. A. Lowenheim, W. W. Sellers, and F. X. Carlin (Abstract No. 60)

2:40 P.M.—"Electrodeposition of Manganese and Manganese Alloys: A Literature Survey" by E. L. MacNamara (Abstract No. 61)

3:20 P.M.—"Statistical Designs for Corrosion Testing" by W. Rowan (Abstract No. 62)

4:00 P.M.—"Comparison of Salt Spray Corrosion Rates for Tin Plated Copper in Different Locations" by M. S. Frant (Abstract No. 63)

4:40 P.M.—"The Performance of Supplementary Chromate Films on Zinc" by F. R. Nagley, K. L. Procter, and H. L. Katz (Abstract No. 64)

ELECTRODEPOSITION

Tuesday, October 8, 1957
Growth of Electrodeposits
with S. Barnartt presiding
(BUFFALO ROOM)

9:30 A.M.—"Filamentary Growths on Copper Cathodes" by T. C. J. Ovenston, C. A. Parker, and A. E. Robinson
(Abstract No. 65)

10:00 A.M.—"Microstructure of Copper Electrodeposited on Copper" by T. H. Orem
(Abstract No. 66)

10:30 A.M.—"Electron Microscope Studies on Copper Electrodes in Copper Plating Baths" by Shinzo Okada and Saburo Magari (Abstract No. 67)

11:00 A.M.—"The Structure of Electrodeposited Nickel" by B. C. Banerjee and A. Goswami
(Abstract No. 68)

11:30 A.M.—"Effect of Magnesium Sulfate on Nickel Plating Baths" by Ahmad Geneidy, W. A. Koehler, and Willi Machu
(Abstract No. 69)

Electrodeposition (cont'd)
Tuesday, October 8, 1957
with A. Brenner presiding
(BUFFALO ROOM)

2:00 P.M.—"Electroplating of Titanium and Other Polyvalent Metals from Molten Salt Electrolyte" by R. S. Dean, W. W. Gullett, and F. X. McCawley
(Abstract No. 70)

2:30 P.M.—"The Electrolytic Preparation of Titanium from Fused Salts, I. Preliminary Electrolytic Studies with Diaphragmed Cells" by M. B. Alpert, F. J. Schultz, and W. F. Sullivan (Abstract No. 71)

3:00 P.M.—"An Evaluation of Some Factors Involved in the Mechanical Testing of Electrodeposits" by T. J. Whalen and H. J. Read (Abstract No. 72)

3:30 P.M.—"Some Testing Cells for the Study of Electroplating Devices" by J. K. Shwirzynski and M. Huttly
(Abstract No. 73)

4:00 P.M.—Electrodeposition Division Business Meeting in the Buffalo Room.

Electrodeposition (cont'd)

Wednesday, October 9, 1957

Electrolytic Metal Powders with C. A. Snavely presiding

(BUFFALO ROOM)

9:00 A.M.—**"Electrolytic Metal Powders—Production and Applications"** by K. H. Roll (Abstract No. 74)

9:40 A.M.—**"Electrodeposition of Powders for Powder Metallurgy"** by C. L. Mantell (Abstract No. 75)

10:20 A.M.—**"Electrolytic Iron Powders—Production and Properties"** by W. M. Shafer (Abstract No. 76)

11:00 A.M.—**"Electrolytic Iron Powder from a Caustic Bath"** by Adrien Le Duc and Luther Vaaler (Abstract No. 77)

11:40 A.M.—**"Electrolytic Copper Powder—Production and Properties"** by E. J. Clugston and Frank Willis (Abstract No. 78)

ELECTRONICS—SEMICONDUCTORS

Monday, October 7, 1957

Elemental Semiconductors with P. H. Keck presiding

(BALLROOM)

9:30 A.M.-12:00 M.—A complete program including an abstract of each paper will be mailed to the Electronics Division-Semiconductor Group mailing list early in September. The program will also be available at the meeting.

Electronics—Semiconductors (cont'd)

Monday, October 7, 1957

Elemental Semiconductors with S. Angello presiding

(BALLROOM)

2:00 P.M.-5:00 P.M.—A complete program including an abstract of each paper will be mailed to the Electronics Division-Semiconductor Group mailing

list early in September. The program will also be available at the meeting.

Electronics—Semiconductors (cont'd)

Tuesday, October 8, 1957

Semiconductor Compounds and Alloys
with D. A. Jenny presiding
(BALLROOM)

9:30 A.M.-12:00 M.—A complete program including an abstract of each paper will be mailed to the Electronics Division-Semiconductor Group mailing list early in September. The program will also be available at the meeting.

Electronics—Semiconductors (cont'd)

Tuesday, October 8, 1957

Surface Phenomenon
with E. N. Clark presiding
(BALLROOM)

2:00 P.M.-5:00 P.M.—A complete program including an abstract of each paper will be mailed to the Electronics Division-Semiconductor Group mailing list early in September. The program will also be available at the meeting.

Electronics—Semiconductors (cont'd)

Wednesday, October 9, 1957
Diffusion and Process Technology
with M. Tanenbaum presiding
(BALLROOM)

9:30 A.M.-12:00 M.—A complete program including an abstract of each paper will be mailed to the Electronics Division-Semiconductor Group mailing list early in September. The program will also be available at the meeting.

ELECTRO-ORGANIC

Monday, October 7, 1957
Arc Electrolysis
with M. J. Allen presiding
(EMPIRE STATE ROOM)

10:00 A.M.—"Glow-Discharge Electrolysis in Aqueous Solutions"

by A. R. Denaro and A. Hickling (Abstract No. 79)

Cathodic Reduction of Organic Compounds

10:30 A.M.—"Electrolytic Reduction of Cyanamide, II. Nature of the Reduction of Cyanamide and Formamidine" by Keijiro Odo, Eiichi Ichikawa, Katsujiro Shimogai, and Kiichiro Sugino (Abstract No. 80)

11:00 A.M.—"Electrolytic Reduction of Organic Compounds, VII. Furfural" by D. D. Staker and and C. L. Wilson (Abstract No. 81)

11:30 A.M.—"Electrolytic Reduction of Organic Compounds, VIII. Acetone" by G. W. Mansel and C. L. Wilson (Abstract No. 82)

12:30 P.M.—Electro-Organic Luncheon and Business Meeting in the New York Room.

Electro-Organic (cont'd)

Monday, October 7, 1957

Cathodic Reduction of Organic Compounds
with G. W. Thiessen presiding

(EMPIRE STATE ROOM)

2:00 P.M.—"An Electrolytic Study of the Course of the Clemmensen Reduction" by R. A. Strehlow and Sherlock Swann, Jr. (Abstract No. 83)

2:30 P.M.—"Application of Electrodialysis to Halide Interconversion in Quaternary Salts" by M. J. Allen and J. Ocampo (Abstract No. 84)

3:00 P.M.—"Electrochemical Reduction of the C_4 Dibasic Acids and Their Esters: Acetylenedicarboxylic, Dibromomaleic, and Dibromofumaric. Nature of the Products and Reaction Mechanisms" by P. J. Elving, Isadore Rosenthal, J. R. Hayes, and A. J. Martin (Abstract No. 85)

3:30 P.M.—Round-table discussion on the **Industrial Future of Electro-Organic Chemistry** with M. J. Allen, S. Swann, and C. L. Wilson.

Electro-Organic (cont'd)
Tuesday, October 8, 1957
Polarography
with S. Wawzonek presiding
(LOS ANGELES ROOM)

9:00 A.M.—"Solid Electrode Voltammetry of Organic Compounds" by Theodore Kuwana, T. R. Mueller, and R. N. Adams (Abstract No. 86)

9:30 A.M.—"Electrochemical Studies in Cyclic Carbonate Esters" by C. W. Tobias (Abstract No. 87)

10:00 A.M.—"Polarographic Studies in Dimethylformamide, IV. Behavior of Aldehydes and Ketones" by S. Wawzonek and A. A. Gundersen (Abstract No. 88)

10:30 A.M.—"Polarographic Reduction of Some Acetylenic Linkages" by A. H. Gropp and J. C. Ramsey, Jr. (Abstract No. 89)

11:00 A.M.—"Polarographic Reduction of Some Nitrofluorenones" by Julia Gary, R. M. Powers, and R. A. Day, Jr. (Abstract No. 90)

Electro-Organic (cont'd)
Tuesday, October 8, 1957
Polarography
with P. J. Elving presiding
(LOS ANGELES ROOM)

2:00 P.M.—"Electrochemical Reduction of Some Nitramines and Nitrosamines, I. Polarographic Behavior of Some Alkyl and Aryl Nitrosamines" by G. C. Whitnack, R. D. Weaver, and H. W. Kruse (Abstract No. 91)

2:30 P.M.—"A Polarographic Study of Sodium-iodomethane Sulfonate in Various Media" by M. J. Allen and V. J. Powell (Abstract No. 92)

3:00 P.M.—"Polarographic Behavior of Iodinated X-Ray Contrast Agents" by Peter Kabasakalian (Abstract No. 93)

3:30 P.M.—"Polarography of Organo Tin Halides" by C. M. Wheeler, Jr. (Abstract No. 94)

4:00 P.M.—"Polarographic Behavior of Steroids" by Peter Kabasakalian (Abstract No. 95)

Electro-Organic (cont'd)
Thursday, October 10, 1957
Polarography
with S. Wawzonek presiding
(EMPIRE STATE ROOM)

9:00 A.M.—"Correlation of Polarographic Half-Wave Potentials with Nuclear Magnetic Resonance 'Chemical Shifts'" by C. E. Bennett and P. J. Elving (Abstract No. 96)

9:30 A.M.—"Correlation of Polarographic Half-Wave Potentials of Organic Compounds" by P. J. Elving and C. E. Bennett (Abstract No. 97)

10:00 A.M.—Round-table discussion on the **Application of Polarographic Techniques in the Pharmaceutical Field,** with M. J. Allen as Chairman, and Mr. Peter Kabasakalian.

ELECTROTHERMICS AND METALLURGY

Monday, October 7, 1957
General Session
with G. M. Butler presiding
(NEW YORK ROOM)

2:00 P.M.—"Equilibria between Titanium Metal and Solutions of Titanium Dichloride in Fused Sodium Chloride" by K. Komarek and P. Herasymenko (Abstract No. 98)

2:30 P.M.—"Reaction Kinetics of the Nitriding of Titanium Dioxide" by D. L. Douglass, J. H. Borden, and G. R. St. Pierre (Abstract No. 99)

3:00 P.M.—"Continuous Electrolytic Process for the Production of High Purity Beryliium Metal" by S. J. Morana (Abstract No. 100)

3:30 P.M.—"Equilibrium Reduction of Tungsten Oxides by Hydrogen" by R. C. Griffis (Abstract No. 101)

Electrothermics and Metallurgy (cont'd)
Tuesday, October 8, 1957
Ferroalloys and Slags
with E. T. Johnson presiding
(GEORGIAN ROOM)

9:15 A.M.—Opening remarks by E. T. Johnson

9:25 A.M.—"A Review of the Uses and Markets for Ferroalloys" by R. W. Hale (Abstract No. 102)

10:05 A.M.—"Metallurgical Design of Submerged Arc Furnaces" by W. M. Kelly (Abstract No. 103)

10:45 A.M.—"Electric Smelting of Low Grade Nickel Ores" by L. H. Banning (Abstract No. 104)

11:15 A.M.—"Dissociation and Electrical Conductivity of Molten Silicates" by Axel Wejnarth (Abstract No. 105)

Electrothemics and Metallurgy (cont'd)

Wednesday, October 9, 1957

with A. C. Haskell presiding

(EMPIRE STATE ROOM)

9:30 A.M.—"Ferroalloys from Low Grade Ores by the Udy Processes" by M. C. Udy and M. J. Udy (Abstract No. 106)

10:00 A.M.—"Experimental Production of Iron, Silicospiegeleisen, and Portland Cement from a Low Grade Manganiferous Iron Ore" by R. A. Campbell, G. N. Banks, and R. R. Rogers (Abstract No. 107)

10:30 A.M.—"Small Single Phase, Dry-Top Electric Furnace for Experimental Smelting of Manganese Ores" by D. D. Blue (Abstract No. 108)

11:00 A.M.—"Electrodeposition of High Purity Chromium" by F. E. Block, P. C. Good, and G. Asai (Abstract No. 109)

ABSTRACTS

In the Index to Authors, the Abstract Number is the number listed in the right-hand column.

BATTERY

Abstract No. 1

The Anodic Oxides on Lead

Jeanne Burbank, U. S. Naval Research Lab., Washington 25, D. C.

The anodic oxides formed on Pb under varying potential and pH were identified by x-ray and electron diffraction. The potential-pH phase diagram of Pb has been expanded by

definition of the crystalline phases present as electrode species. The lamellar nature of the anodic product formed on Pb under conditions obtaining in the Pb-acid cell is interpreted on the basis of the diagram.

Abstract No. 2

The Electrochemical Properties of PbO_2 and the Anodic Corrosion of Lead and Lead Alloys

Paul Ruetschi, Research Dept., Electric Storage Battery Co., P. O. Box 5723, Philadelphia 20, Pa.

Since the electric and electrochemical properties of the alpha and beta forms of PbO_2 depend on their oxygen lattice defects, x-ray diffraction patterns and electrode potential measurements have been made on a series of lead oxides formed by thermodecomposition of PbO_2.

Anodic polarization of lead in H_2SO_4 under conditions of oxygen evolution leads to layers of α-PbO_2 with excess oxygen in the surface. The amount of excess oxygen is related to oxygen overvoltage and corrosion. This study has also included a large series of lead alloys.

Abstract No. 3

The Correction of X-Ray Diffraction Powder Photographs for Highly Absorbing Samples*

P. E. Jensen and **E. J. Ritchie,** Eagle-Picher Research Labs., Joplin, Mo.

The interpretation of x-ray diffraction powder photographs is based on the precise determination of the line positions. From highly absorbing materials, as lead oxide, the diffraction pattern arises from a very thin surface layer and with a cylindrical sample the diffraction line is displaced a variable amount at different 2θ angles. A method of line measurement and correction was developed which yields line position data of higher precision than the usual method of correcting for sample diameter.

* This work sponsored by Office of Naval Research Contract number Nonr 1513(00).

Abstract No. 4

The Unit Cell of Yellow Litharge*

P. E. Jensen and **E. J. Ritchie**, Eagle-Picher Research Labs., Joplin, Mo.

Observed physical properties of various yellow litharge preparations suggest a much larger unit cell of perhaps different symmetry at high temperatures but for which the usually accepted orthorhombic cell is a related substructure at room temperature. It appears probable that the large unit cell may persist at room temperature to a varying degree determined by impurities and the history of the sample.

* This work sponsored by Office of Naval Research Contract Nonr 1513(00).

Abstract No. 5

Changes in Positive Active Material Density during Various Conditions of Service

J. F. Dittmann and **J. F. Sams**, Eagle-Picher Research Labs., Joplin, Mo.

Observations made on the lead-acid battery indicated that changes were occurring in the apparent density of the positive active material during service. To determine the extent of these density changes, measurements have been conducted during and under all conditions of testing. The apparent density of the positive active material has been found to decrease regardless of active material shedding. This finding may explain many observed performance characteristics of the lead-acid battery.

Abstract No. 6

The Action of Silver and Cobalt at the Positive Plate of the Lead-Acid Battery

J. J. Lander, Electric Auto-Lite Co., Toledo 1, Ohio

The electrochemical action of Ag and Co at the positive plate of a Pb-acid battery is explained. Corrosion rates of positive grids have been determined over the range of voltages which the positive plate can experience in service and on the SAE Overcharge Test. The protective effect of Ag and Co on the SAE test follows from the explanation and the

corrosion data. These results are discussed in terms of positive grid life in passenger car service.

Abstract No. 7

Influence of Positive Grid Alloy and Element Design on Battery Performance

H. Stoertz, Research Dept., Electric Storage Battery Co., P. O. Box 5723, Philadelphia 20, Pa.

While such additives as As and Ag enhance the corrosion resistance of positive grids, selection of the proper Sb content is likewise important and contributes to battery performance by means of increased life and lower negative sulfation. The maximum benefit residing in the use of lower Sb content as well as added As and/or Ag can be obtained only when positive active material is prevented from shedding. This can be accomplished by selection of suitable plate construction or suitable element design.

Abstract No. 8

Design and Quality Control in the Battery Industry through Microscopy

A. C. Simon and **E. L. Jones,** U. S. Naval Research Lab., Washington 25, D. C.

Examples are presented to show how the microscope may be used in the study of all parts of the storage cell. It is shown that a specialized technique of battery examination is available that could be applied to quality control in battery manufacture and also serves as a useful tool in research and development.

Abstract No. 9

Designing for Quality

H. J. Strauss, Research Dept., Electric Storage Battery Co., P. O. Box 5723, Philadelphia 20, Pa.

Modern trends for product engineering have found that they must frequently abandon the classical concepts on which design tolerances and variations are predicated. For example, the principle that assemblies must be satisfactory if all parts, except one, are at one end of the tolerance with the single part at the other end, can result in costly assemblies

whose performance can be severely substandard. Modern concepts require that such assemblies actually do not go together satisfactorily, so as to preclude their introduction into the market. Batteries are particularly amenable to these concepts in that they represent "stacked" assemblies whose tolerances must be carefully balanced out. The principles on which this can be done and the disposition of unsatisfactory assemblies are discussed as related specifically to battery design.

Abstract No. 10

Design Factors for Nickel-Cadmium Batteries

Arthur Fleischer, R. E. Rockey, and **G. B. Ellis,** Nickel Cadmium Battery Corp., Easthampton, Mass.

Battery design is influenced to a large extent by end use and application. The element design is the basic feature in defining the electrical performance. The design of tabs, internal connectors, terminal posts, glands, gas space, sediment space, intercell connectors, and other constructional features is also important for ease of maintenance and long battery life. These features, too often taken for granted, will be illustrated for pocket type and sintered plate-type Ni-Cd batteries.

Abstract No. 11

Improvement in Negative Plate Performance

Arthur Fleischer, Nickel Cadmium Battery Corp., Easthampton, Mass.

Cycling characteristics of the negative Cd electrode have been improved by the discovery of two types of expander, namely, alkali-soluble cellulose derivatives and indium. Experimental studies were based on the repeated charging and discharging of cells with three-plate elements in which the negative electrode was capacity limiting. Conditions for capacity loss or maintenance were defined. Under the conditions of operation showing capacity loss for Cd electrodes of previously known compositions, the incorporation of the new expanders prevents capacity loss and improves performance.

Abstract No. 12

Cinemicrography of the Freezing Process in Lead-Antimony Grid Alloys

A. C. Simon and **E. L. Jones**, U. S. Naval Research Lab., Washington 25, D. C.

The actual freezing process occurring in Pb-Sb alloys is illustrated. Supercooling of the eutectic and a preferred dendritic growth of Sb in the surface layer are found to occur as was postulated previously from theoretical considerations.

Abstract No. 13

Measurement of the Internal Resistance of Standard Cells

G. D. Vincent, Standard Cell Dept., The Eppley Lab., Inc., Newport, R. I.

The internal resistance of standard cells is measured by several methods. For new cells in good condition, the results by different methods are in closer agreement than for old cells or those which have been subjected to high temperatures or current passage. The use of the apparent difference in internal resistance by different methods of measurement as a criterion of the stability of the emf of a standard cell is examined.

Abstract No. 14

A New Approach to Resistance Measurements of Dry Cells

R. J. Brodd, National Bureau of Standards, Washington 25, D. C.

A new technique for measuring resistance of Leclanché cells is described. The resistance of Leclanché cells was measured as a function of size, residual capacity, and current drain.

Abstract No. 15

Formation of Manganese (II) Ion in the Discharge of the Manganese Dioxide Electrode, II. Effect of Volume and *p*H of Electrolyte

W. C. Vosburgh, Mary Jo Pribble, Akiya Kozawa, and **Ahmed Sam**, Dept. of Chemistry, Duke University, Durham, N. C.

Discharge of the MnO_2 electrode at *p*H 5-8 is known to give Mn^{++} in solu-

tion as well as a lower oxide. When the volume of electrolyte is varied, the amount of Mn^{++} is practically independent of volume. It decreases as the pH increases, becoming small at pH 8. The reaction of lower oxides with electrolytes shows a similar relation to volume and pH. These results aid in understanding the discharge process.

Abstract No. 16

The Relation of the Conditions of Electrodeposition of Manganese Dioxide to the Discharge Characteristics

Akiya Kozawa and **W. C. Vosburgh**, Dept. of Chemistry, Duke University, Durham, N. C.

Electrodes were prepared by electrodeposition of MnO_2 at various temperatures and current densities, or with NH_4^+, K^+, Zn^{++}, Mg^{++}, or Al^{+++} in the plating bath. Overpotentials in acid electrolyte, discharge curves in NH_4Cl electrolyte, and the Mn^{++} in solution in the latter case were determined. Differences could be explained as resulting from differences in structure, thickness, or surface area, the latter measured by adsorption of Zn^{++}.

Abstract No. 17

Studies on the Vapor Pressure and the Density of Electrolytes for Dry Cells

Kumazo Sasaki, Dept. of Applied Chemistry, Faculty of Engrg., Nagoya University, Furo-Cho, Chikusa-ku, Nagoya, Japan

Measurements have been made of vapor pressures and densities, as function of temperature at 10°, 18°, 25°, and 32°C, for 50 sample solutions consisting of various mole ratios of NH_4Cl (0~15 mole/kg H_2O) and $ZnCl_2$ (0.5~9.5 mole/kg H_2O). These data, with the vapor pressure and change of specific volume, allow calculations of water activities and salt errors, which appear in the case of determining pH value of the mixed solutions.

Abstract No. 18

A Magnesium Sea-Water Battery

J. J. Shotwell and **R. C. Kirk**, Dow Chemical Co., Texas Div., Free-

port, Texas, and Midland Div., Midland, Mich., respectively.

Performance characteristics for a magnesium anode air-depolarized sea-water battery are described. Voltage and current output and anode efficiency remained favorable through long periods of sustained discharge. The battery appears to have utility for low cost unattended operation of off-shore equipment such as instruments and signal lights.

Abstract No. 19

Ammonia Vapor-Activated Reserve Batteries*

H. S. Gleason and **J. M. Freund**, Eastman Kodak Co., Rochester, N. Y., and **L. J. Minnick** and **W. F. Meyers**, G. & W. H. Corson, Inc., Plymouth Meeting, Pa.

A new type of reserve battery is described. In storage, the solvent for the electrolyte, liquid ammonia, is kept separate from the dry, deliquescent solute. On activation, ammonia vapor is released to condense rapidly in the cells and energize the battery. A large number of practical cells can be built using this principle. Characteristics of several are discussed. Some of the properties of electrolytes in liquid ammonia are also presented.

* This work sponsored by the Dept. of Defense under various contracts.

Abstract No. 20

A Unique Dry Battery

H. B. Reed, Jr., and **M. B. Goldberg**, Naval Ordnance Lab., White Oak, Silver Spring, Md.

A unique dry battery has been developed at the Naval Ordnance Lab. Its greatest asset is storageability under adverse conditions. A storage life of ten years or more is anticipated. One year of storage at 165° has not affected the capacity of this battery. An active life of over 3½ years has been observed. The battery is readily rechargeable. As many as 36 charge-discharge cycles have been measured with little change in capacity. The fully charged unit employs the following electrochemical system $Pb/KOH/Ag_2O$.

Abstract No. 21

Indium as an Anode Material

T. L. Boswell, Elgin National Watch Co., Elgin, Ill.

Indium and indium-bismuth alloys are evaluated as energy producing electrodes for use in small sealed cells. Important electrochemical characteristics of these materials are compared to the commonly used electrode metals and the areas in which significant advantages and disadvantages exist are indicated. The performance of these electrodes has been measured in small sealed cells against a mercuric oxide cathode. Results are discussed in relation to current-carrying ability, electrical capacity, and voltage stability.

Abstract No. 22

Halogen-Activated Solid Electrolyte Cell

J. L. Weininger, Research Lab., General Electric Co., P. O. Box 1088, Schenectady, N. Y.

A new type of silver-halide solid-electrolyte cell consists of a small bead of silver halide with tantalum and silver wires, cathode and anode, respectively. The mechanism of the electrochemical reaction has been determined. When exposed to halogen vapor, the cell is a promising primary cell for elevated temperatures. With silver iodide as electrolyte, the cell can be recharged several times.

Abstract No. 23

An Investigation of Some New Cathode Depolarizer Materials

A. B. Tripler, Jr., and **L. D. McGraw,** Electrochemical Engrg. Div., Battelle Memorial Institute, Columbus 1, Ohio

The electrochemical behavior and charge retention of manganic phosphate, barium ferrate, and chloranil (tetrachloroquinone) are described. The electrochemically active materials, mixed with carbon, have observed capacities of 8, 4, and 6 w-min/g, respectively, when discharged as cathodes at rates of 200 ma/in.^{2} for the first two, and 100 ma/in.^{2} for the third. The kinetic limitations for the electrode processes are discussed.

Abstract No. 24

Investigations of Electrochemical Characteristics of Organic Compounds, I. Aromatic Nitro Compounds

R. Glicksman and **C. K. Morehouse**, RCA Labs., Radio Corp. of America, Princeton, N. J.

A study of the electrochemical characteristics of aromatic nitro compounds shows that the cathode potential of these compounds during current flow is dependent on the type and position of substituted groups on the aromatic ring, as well as the composition and pH of the electrolyte. Coulometric reduction studies of various mono and dinitro aromatic compounds indicate reduction of these compounds takes place to the amino stage, with a resultant 6 electron change per $-NO_2$ group, at electrode efficiencies of 70-90%.

Abstract No. 25

Nitro Aromatic-Magnesium Dry Cells

C. K. Morehouse and **R. Glicksman**, RCA Labs., Radio Corp. of America, Princeton, N. J.

Many aromatic nitro compounds when coupled with a magnesium anode and a $MgBr_2$ electrolyte give dry cells with practical features, the discharge characteristics being dependent on the type of nitro aromatic compound used as a cathode. The meta dinitrobenzene-magnesium dry cell has been thoroughly characterized, and shown to have a favorable shelf life, and give greater watt-hour capacities per unit of weight and volume than the commercial Leclanché cell.

Abstract No. 26

Investigations of Electrochemical Characteristics of Organic Compounds, II. Aromatic Nitroso Compounds

R. Glicksman and **C. K. Morehouse**, RCA Labs., Radio Corp. of America, Princeton, N. J.

This study has shown that C-nitroso organic compounds operate at a higher discharge potential than

their corresponding nitro organic compounds, as well as the various oximes, N-nitroso, and N-oxide organic compounds tested. A limited study of the various C-nitroso organic compounds has shown that the discharge potential is pH dependent, and is affected by the type and position of the substituted group on the aromatic ring.

Abstract No. 27

Nitroso Aromatic-Magnesium Dry Cells

C. K. Morehouse and **R. Glicksman,** RCA Labs., Radio Corp. of America, Princeton, N. J.

Dry cells have been made using various C-nitroso aromatic compounds and cathodes coupled with a magnesium anode. These cells, which operate at higher discharge potentials than corresponding nitro aromatic-magnesium dry cells, have characteristics which are dependent on the type of nitroso compound used as a cathode. The p-nitrosodimethylaniline-magnesium dry cell has been fully characterized, and shown to operate at a flat voltage level between 1.3 and 1.4 v, and give greater watt-hour capacities per unit of weight and volume than the commercial Leclanché dry cell.

Abstract No. 28

N-Halogen Organic Reserve Batteries

G. S. Lozier, L. H. Cutler, and **C. K. Morehouse,** RCA Labs., Radio Corp. of America, Princeton, N. J.

N,N'dichlorodimethylhydantoin, trichloromelamine, hexachloromelamine, trichloroisocyanuric acid, and dichloroisocyanuric were found to be the most promising N-halogen organic compounds for use in the design of a high capacity reserve battery. Experimental N-halogen organic-magnesium reserve cells have been constructed, using a titanium positive electrode and a dry formed cathode. These cells have a capacity of 1.5-1.6 amp-hr, and give capacities of over 50 whr/lb and 2 whr/ $in.^3$, allowing a 20% voltage drop.

Abstract No. 29

The Germanium-Water-Oxygen System: Kinetics of the Dissolution Process*

W. W. Harvey and **H. C. Gatos,** Lincoln Lab., Massachusetts Institute of Technology, Lexington, Mass.

The reaction of crystallographically oriented Ge surfaces with water has been shown to depend primarily on concentration of dissolved oxygen and temperature. It is not affected significantly by the concentration of mobile carriers in Ge. Thus, illumination has no effect on the dissolution rate. Dissolution rates have been measured for single-crystal specimens of various orientations, the observed order being $\{100\} > \{110\} > \{111\}$. A mechanism for the reaction is proposed.

* The research reported in this document was supported jointly by the Army, Navy, and Air Force under contract with M.I.T.

Abstract No. 30

Oxidation of Copper Single Crystals in Oxygen-Saturated Water at Room Temperature*

Jerome Kruger, U. S. Dept. of Commerce, National Bureau of Standards, Washington 25, D. C.

Studies of the oxide films formed on the surfaces of Cu single crystals exposed under rigidly controlled conditions to high purity water saturated with oxygen at room temperature are described. The influence of crystallographic orientation of the reacting surface, presence of CO_2, and illumination by white light on relative rate of film growth, nature of oxide, oxide morphology, and metal-oxide epitaxy were investigated.

* This work is supported in part by the Corrosion Research Council.

Abstract No. 31

Metal-Water Reactions, IV. Kinetics of the Reaction between Calcium and Water Vapor

H. J. Svec and **Charles Apel,** Institute for Atomic Research and Department of Chemistry, Iowa State College, Ames, Iowa

Calcium metal was reacted with water vapor in the temperature

range 20°-70°C and at water vapor pressures of 18-93 mm Hg. The experiments indicated that the only products were calcium hydroxide and hydrogen and that the reaction proceeded according to the equation

$$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$$

A manometric study of the reaction showed that it followed the logarithmic rate law,

$$W = K \log (1 + 0.45t)$$

The rate constant K was observed to be linearly dependent on water vapor pressure below 70°C and to decrease with increasing temperature in the range 20°-50°C. At 70°C the rate constant was observed to be independent of water vapor pressure. The activation energy was found to be —7.52 kcal/mole in the pressure dependent range. Temperature and water vapor pressure were related to the rate constant K in its pressure dependent ranges and the following expression fits the data for water vapor pressures greater than 10 mm Hg:

$$K = 2.57 \times 10^{-5} (P—10)\, e^{3735/T}$$

Abstract No. 32

Metal-Water Reactions, V. Kinetics of the Reaction between Magnesium and Water Vapor

H. J. Svec and **D. S. Gibbs,** Institute for Atomic Research and Department of Chemistry, Iowa State College, Ames, Iowa.

The rate of reaction between magnesium and water vapor was studied in the temperature range between 425° and 575°C and in the water vapor pressure range between 31 and 208 mm Hg. The reaction took place according to the linear rate law. Rate constants were found to be linearly dependent on the water vapor pressure. The activation energy for the reaction was found to vary with both temperature and water vapor pressure, increasing as the temperature was increased and the water vapor pressure was decreased. This type of variation is explained on the basis of a change from a surface to a vapor pressure of magnesium metal in the temperature range between 500° and 600°C.

Abstract No. 33

Electrochemical Polarization, III. Further Aspects of the Shape of Polarization Curves

Milton Stern, Metals Research Labs., Electro Metallurgical Co., P. O. Box 580, Niagara Falls, N. Y.

The shape of electrochemical polarization curves is discussed for systems containing more than two oxidation-reduction reactions. Conditions were selected which parallel those found in practice for corroding systems. Situations are described where measured Tafel parameters have no direct relationship to the parameters of any of the oxidation-reduction reactions. The analysis shows the complexity of polarization measurements and indicates the care which must be taken if such measurements are to be interpreted quantitatively.

Abstract No. 34

Electrochemistry of Magnesium

G. R. Hoey and **M. Cohen,** National Research Council, Ottawa, Canada

The effect of current density, *p*H, and temperature on the anodic behavior, cathodic behavior, and corrosion of Mg in aqueous solutions has been studied. A tentative mechanism for the anodic oxidation of Mg was postulated. Local corrosion and undermining of metallic Mg at the anode are appreciable and may, in fact, account for the observed low anodic current efficiencies of Mg. An intergranular type of corrosion occurs at cathodically polarized Mg at the elevated temperatures. A hydrogen embrittlement theory was proposed to explain intergranular cathodic corrosion. Anodic and cathodic polarization curves of Mg are reported.

Abstract No. 35

Use of High Purity Aluminum and Its Alloys in Controlling the Corrosion of Magnesium Alloys, I. The Galvanic Compatibility of Aluminum Alloys with Magnesium Alloys

M. R. Bothwell, Chemical Section, Metallurgical Lab., The Dow Chemical Co., Midland, Mich.

Its extremely high hydrogen overvoltage and freedom from depolarization by dissolved oxygen make high purity Al almost completely compatible with Mg alloys in saline environments. Alloying the Al with small amounts of low overvoltage metals such as Fe, Cu, and Ni seriously decreases this compatibility, but the tolerance for these constituents is greatly increased by alloying with Mg.

Abstract No. 36

Use of High Purity Aluminum and Its Alloys in Controlling the Corrosion of Magnesium Alloys, II. The Protection of Magnesium Alloys by Aluminum

M. R. Bothwell, Chemical Section, Metallurgical Lab., The Dow Chemical Co., Midland, Mich.

Because of its remarkable galvanic compatibility and excellent resistance to corrosion in most service environments, high purity Al is an extremely promising coating material for Mg alloys. The corrosion resistance of these coated composites is very sensitive to low overvoltage impurities in the coating during exposure to NaCl solution and less sensitive during exposure to sea water which buffers the system at a lower pH and thus better controls alkaline attack of the coating.

Abstract No. 37

Reaction of Aluminum and Carbon Tetrachloride, I

J. D. Minford, M. H. Brown, and **R. H. Brown,** Research Labs., Aluminum Co. of America, New Kensington, Pa.

Many Al alloys are severely corroded by boiling CCl_4. The major products of the reaction are aluminum chloride and hexachloroethane. The presence of anhydrous aluminum chloride accelerates the reaction. A number of chemical agents can retard this reaction apparently by combining with aluminum chloride as it is produced. The reaction of Al alloys drops off rapidly as the Mg content increases.

Abstract No. 38

Reaction of Aluminum and Carbon Tetrachloride, II

R. H. Brown, E. H. Cook, M. H. Brown, and **J. D. Minford,** Research Labs., Aluminum Co. of America, New Kensington, Pa.

The mechanism of the reaction between Al and boiling CCl_4 appears to be electrochemical. Conductivity measurements indicate that the reaction starts as soon as the Al is exposed to the boiling solution. The increase in conductivity with time is caused by the presence of $AlCl_3$ and parallels the increase in weight per cent Al as the reaction proceeds. The application of a cathodic current prevents attack of an Al specimen, indicating that the initial attack is caused by the presence of an ionic species. Trace amounts of the reaction product hexachloroethane were produced electrochemically in the absence of any Al.

Substances that retard the reaction apparently function by forming inactive complexes with the $AlCl_3$. The rate-determining step in the reaction does not appear to involve free radicals since the majority of the effective inhibitors failed to react with known free radicals.

Abstract No. 39

Accelerated Corrosion in Aluminum-Silver Alloys

H. H. Stadelmaier and **E. M. Whitener,** Dept. of Engrg. Research, North Carolina State College, Raleigh, N. C.

In the presence of photographic developer, Al-rich Al-Ag alloys corrode in air by a mechanism that is accelerated by the tendency of the developer to reduce the precipitated compound $AlAg_2$ to Ag. This reduction occurs only at preferred sites in pure $AlAg_2$ but is quite general in the precipitated compound.

Abstract No. 40

Room Temperature Tarnishing of Silver in Bromine and Iodine

J. L. Weininger, Research Lab., General Electric Co., P. O. Box 1088, Schenectady, N. Y.

Pure Ag was tarnished in an atmosphere of iodine or bromine va-

por at room temperature. This resulted in impervious halide surface layers, from which tarnishing rates could be deduced by means of a new photomicrographic technique. It was found that the parabolic rate law, with diffusion being the rate-determining step, also holds at room temperature. The effect of pretreatment of Ag on the rate of halogenation is discussed.

Abstract No. 41

Effect of Steel, Passivating Solution, and Corrosive Media Variations on the Electrochemical Method of Detecting Hydrogen Diffusion through Steel

T. J. Butler, Applied Research Lab., U. S. Steel Corp., Monroeville, Pa.

If one side of a steel specimen corrodes in a media in which the formation of hydrogen is at least part of the cathodic reaction, some of the hydrogen in the atomic state will diffuse through the steel. This diffused hydrogen can destroy the passivity imparted to another surface of the steel specimen, as is evidenced by a change in potential of the passive surface from noble to active values. Passivating solutions (such as dichromates, permanganates, NaOH, concentrated HNO_3, and some salt solutions) and hydrogen-producing corroding media (such as various acids, KCl, sodium sulfate, and distilled water) were studied. Steel specimens were chosen from lots of tin-plate steels, stainless steels, and enameling steels.

Abstract No. 42

Cathodic Reduction of Oxide Films on Iron, II. Determination of α- Fe_2O_3 and Fe_3O_4

K. H. Buob, A. F. Beck, and **M. Cohen,** National Research Council, Ottawa, Canada

A study of the cathodic reduction of α-Fe_2O_3 on Fe has been made with the object of using the technique for the accurate determination of both the α-Fe_2O_3 and Fe_3O_4 formed during the oxidation of Fe. The films were examined after oxidation and after various stages of cathodic reduction. Examination was

made by weight change, electron diffraction, x-ray diffraction, and chemical analysis of the films. Some evidence for the existence of a thin layer of α-Fe_2O_3 between the layers of Fe_3O_4 and α-Fe_2O_3 was found. A standard pattern for Fe_3O_4 was obtained.

Abstract No. 43

Chemical Factors Affecting Stress Corrosion Cracking of 18-8 Stainless Steels

H. H. Uhlig and **John Lincoln, Jr.,*** Corrosion Lab., Dept. of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.

Fundamental studies show that transgranular stress corrosion cracking of 18-8 in boiling 42% $MgCl_2$ is accelerated by additions of acid, and decelerated by additions of alkali. Oxygen or other depolarizers are accelerators. Pre-exposure of unstressed specimens to the test solution slightly decreases cracking time of subsequently stressed specimens. Cracks propagate at the rate of 0.5-1 cm/hr. Sizeable pits are not necessary to initiate cracks in $MgCl_2$, but in NaCl solutions they act as reservoirs for concentrated $FeCl_3$ solution, which like $MgCl_2$ causes rapid cracking. Cracking time was found independent of rate of stressing, and was decreased by cold work. Stress-relief anneal at 375°C for 2 hr did not avoid susceptibility. Cracking can be prevented by cathodic protection at a C.D. greater than 0.03 ma/cm^2.

* Present address: Esso Standard Oil Co., 30 Beachman, Everett, Mass.

Abstract No. 44

The Effect of Gamma Irradiation on the Potential Behavior of Platinum and Stainless Steel Electrodes

W. E. Clark, Chemistry Div., Oak Ridge National Lab., P. O. Box P, Oak Ridge, Tenn.

Electrode potentials of stainless steel and of Pt in 0.1*N* H_2SO_4 at 85°C were measured in a gamma source giving a dose rate of 8.5×10^{17} ev/g water-minute. The potential behavior of the electrodes is believed to depend on the balance between oxidizing and reducing species in solu-

tion which is determined by the products of the radiolysis of water and their reactions with each other and with the particular atmosphere employed.

Abstract No. 45

The Diffusion of Oxygen in Zirconium

J. P. Pemsler, Nuclear Metals, Inc., Cambridge, Mass.

The diffusion of oxygen in zirconium has been determined at 400°-585°C by measuring the rate at which the metal dissolves anodically deposited oxide films. The diffusion coefficient depends on grain orientations, varying by a factor of two among different orientations. Macroscopically observed average values obey the equation $D_{cm^2/sec} = 9.4 \exp] -(51{,}780 \pm 220)/RT]$. The oxidation rate has an orientation dependence similar to the diffusion coefficient, so that adjacent grains in a matrix grow oxide at greatly different rates.

Abstract No. 46

Formation Fields and Current Efficiencies in the Anodic Oxidation of Zirconium: A Direct Comparison of High Potential Formation Fields with Those Derived from Low Potential Charging Curves

G. B. Adams, Jr., T. S. Lee (present address: Research Labs., Westinghouse Electric Corp., Pittsburgh 35, Pa,), and **Pierre Van Rysselberghe** (present address: Dept. of Chemistry, Stanford University, Stanford, Calif.) Dept. of Chemistry, University of Oregon, Eugene, Oreg.

Formation fields at selected constant currents were obtained from high potential unitary formation rates and polarographic current efficiency measurements carried out over the potential range, 20-130 v. These values are compared with formation fields derived from low potential unitary formation rates alone, in the potential range below 2 v.

Results are reported for abraded Kroll process metal at 750 $\mu a/cm^2$, for abraded and chemically polished iodide process metal at 100 and 750 $\mu a/cm^2$, and at 100 $\mu a/cm^2$, respec-

tively. Ionic current efficiencies are reported for several current densities in the high potential range and for the low potential localized oxygen evolution process.

Abstract No. 47

The Reaction of Zirconium with Water Vapor at Subatmospheric Pressures

M. W. Mallett, W. M. Albrecht, and **R. E. Bennett,** Battelle Memorial Institute, 505 King Avenue, Columbus 1, Ohio

The reaction of iodide zirconium with water vapor at 33 mm of mercury pressure was investigated in the range 300°-600°C. The rates follow a cubic law. The cubic rate constant in $(\mu g/cm^2)^3/sec$ is $k = 6.71 \times 10^8 \exp(-29{,}700/RT)$ where 29,700 = 700 cal/mole is the activation energy. Reaction films of monoclinic ZrO_2 are *N*-type semiconductors. Therefore, it is concluded that the mechanism of film formation is the same as that for the zirconium-oxygen reaction.

Abstract No. 48

Reaction of Hydrogen with Preoxidized Zircaloy-2

E. A. Gulbransen and **K. F. Andrew,** Research Labs., Westinghouse Electric Corp., Pittsburgh 35, Pa.

The permeability of preformed oxide films to hydrogen at 300°-400°C was studied. Two types of reactions were observed. If the oxide film was permeable, a general reaction occurred with the formation of zirconium hydride phases on the surface. If the oxide film was relatively impermeable, reaction occurred at the edges of the sample where defects probably exist in the oxide. The reaction starts at localized areas and spreads through the metal with hydride continually spalling from the metal.

Abstract No. 49

The Effect of Pre-Oxidation in Oxygen on the Steam Corrosion Behavior of Zircaloy-2

D. E. Thomas and **S. Kass,** Atomic Power Div., Bettis Field, Westinghouse Electric Corp., P. O. Box 1468, Pittsburgh 30, Pa.

The effect of pre-oxidation in dry oxygen gas on the corrosion behavior of Zircaloy-2 and unalloyed Zr in steam was investigated. In the case of Zircaloy-2 pre-oxidation has no effect on corrosion behavior, the kinetics being the same whether all or part of the total exposure is in oxygen. A transition in kinetics from quasi-cubic to linear occurs in the corrosion of Zircaloy-2 in either medium, indicating that the transition is not associated with corrosion product hydrogen. On the other hand, unalloyed Zr shows neither transition nor breakaway (spalling) when exposed to oxygen, and exhibits breakaway on exposure to steam whether pre-oxidized or not, suggesting that breakaway is associated with corrosion product hydrogen. The phenomena of breakaway and transition are shown to be distinctly different.

Abstract No. 50

Electrolytic Etching of Dense Tantalum

A. L. Jenny and **R. A. Ruscetta,** Capacitor Dept., General Electric Co., Hudson Falls, N. Y.

Dense Ta in the form of 0.0005 in. thick foil can be electrolytically etched in substantially nonaqueous systems containing a variety of solutes. Magnification of the surface area is determined by capacitance measurements and described as a function of polarization voltage. The effects of concentration of solute, anodic current density, operating temperature, moisture content of bath, and condition of the metal surface are described.

Abstract No. 51

Metallographic Manifestations of the Air Oxidation of Tantalum at 750°C

Robert Bakish, Sprague Electric Co., North Adams, Mass.

Experiments describing the air oxidation of Ta at 750°C are presented. The crystallographic factors in the segregation of Ta_2O_5 are presented. A mechanism for the conversion of metal to oxide is proposed.

Abstract No. 52

Nucleation of Crystalline Ta_2O_5 during Field Crystallization

D. A. Vermilyea, General Electric Co., Research Lab., Schenectady, N. Y.

Nucleation during field crystallization of amorphous Ta_2O_5 films occurs at heterogeneities on the metal surface. The time between the application of the field and the appearance of the first crystals corresponds to growth to critical size of a crystal on one of the nucleation sites. The logarithm of the incubation period increases linearly with decreasing electric field at constant temperature. Possible mechanisms for the nucleation of crystals under these conditions are discussed.

Abstract No. 53

Ionic Conductivity of Anodic Films at High Field Strengths: Transient Behavior

D. A. Vermilyea, Research Lab., General Electric Co., Schenectady, N. Y.

Studies of the changes in ionic conductivity of anodic Ta_2O_5 films following rapid changes of applied voltage or following a heat treatment of the film have shown that the activation energy and the activation distance for ionic motion vary with changes in the temperature and electric field strength at which the film is grown. An explanation of these effects in terms of changes in the structure of the film is discussed.

Abstract No. 54

Annealing Anodic Ta_2O_5 Films: Changes in Dissolution Behavior and X-Ray Scattering

D. A. Vermilyea, Research Lab., General Electric Co., Schenectady, N. Y.

When an anodic Ta_2O_5 film is heated to temperatures up to 600°C the rate of dissolution of the film in HF decreases and the x-ray diffraction from the film becomes sharper. It is believed that these changes are the result of changes in local ionic configuration in the film.

Abstract No. 55

Effect of Ultraviolet Irradiation on the Growth of Anodic Ta_2O_5 Films

D. A. Vermilyea, Research Lab., General Electric Co., Schenectady, N. Y.

When a growing anodic Ta_2O_5 film is irradiated with ultraviolet light the film is transformed to a material of different physical and chemical properties, and the film growth is accelerated. The nature of the transformed film and a possible mechanism for the transformation are discussed.

CORROSION - ELECTRODEPOSITION

Abstract No. 56

The Mechanism of Corrosion of Copper-Nickel-Chromium Coatings

H. J. Read, Dept. of Metallurgy, College of Mineral Industries, Pennsylvania State University, University Park, Pa.

The mechanism of selective corrosion of Cu under Ni in Cu-Ni-Cr coatings is explained on the basis of the modern electrochemical theory of corrosion and simple laboratory experiments which simulate conditions that could prevail in the corrosion of practical parts such as automobile bumpers. The interpretation is supported by photomicrographs showing in cross section the progress of corrosion in test bumpers which have been weathered outdoors.

Abstract No. 57

Double Nickel Coatings

B. B. Knapp and **R. J. McKay,** Research Lab., International Nickel Co., Bayonne, N. J.

Composite coatings of Cu and Ni have been used extensively for numerous reasons as an undercoat for a decorative Cr finish. Recently the American Society for Testing Materials, in studying performance tests on electrodeposited coatings, discovered that a coating of two layers of Ni was superior to a single layer and even to a coating of Cu-Ni com-

posite. This paper examines the data on both the preparation and exposure of these coatings and scrutinizes their microstructure to determine if a plausible explanation can be advanced to account for this behavior.

Abstract No. 58

Effects of Acoustical Waves on the Electrodeposition of Chromium*

Joseph Dereska (National Carbon Research Labs., Parma, Ohio), **Ernest Yeager,** and **Frank Hovorka,** Dept. of Chemistry, Western Reserve University, Cleveland, Ohio

The effects of acoustical waves on Cr electrodeposition have been examined at 10 and 260 kc/sec as functions of plating solution formulation, current density, temperature, and acoustical intensity. Some improvements in hardness, porosity, and adhesion were found at both frequencies. The current range of bright deposits is shifted to higher values while grain size is generally decreased. Data for polarization and current efficiencies will also be presented.

*Research partially supported by the Ordnance Corps of the U. S. Army.

Abstract No. 59

Electrodeposition of Chromium Alloys—A Literature Review

Charles Levy, Watertown Arsenal Labs., Watertown, Mass.

Methods have been reported in the periodical and patent literature for electrodeposition of Cr-base alloys. The alloying elements of interest for high temperature protection of materials include W, Mo, Co, Ni, Fe, Ta, and Nb. It is anticipated that further research in this field will yield plating methods which are both practical and economical.

Abstract No. 60

The Protective Value of Tin-Nickel Alloy Deposits on Steel

F. A. Lowenheim, Metal & Thermit Corp., Rahway, N. J., and **W. W. Sellers** and **F. X. Carlin,** International Nickel Co., Bayonne, N. J.

Outdoor exposure tests of the comparative value of the Sn-Ni alloy and conventional Ni/Cr deposits on steel, with and without a copper undercoat, are reported. It is shown that Sn-Ni is comparable in protective value to Ni/Cr, not quite so good in marine but superior in industrial atmospheres. The type of corrosion behavior of the two deposits differs considerably. In general, the protective value of the Sn-Ni deposit is of a high order.

Abstract No. 61

Electrodeposition of Manganese and Manganese Alloys: A Literature Survey

E. L. MacNamara, Ordnance Corps., Frankford Arsenal, Philadelphia, Pa.

Synopses of 62 publications concerning the deposition of Mn and its alloys is presented. Electrolyte formulations, operating conditions, and corrosion data are discussed. Aqueous solutions of manganese sulfate and manganese chloride were in most cases reported as the superior electrolytes. Information on other simple salts was available, but not extensive.

Abstract No. 62

Statistical Designs for Corrosion Testing

W. Rowan, Metal & Thermit Corp., 1700 E. Nine Mile Rd., Detroit 20, Mich.

The field of corrosion testing provides an excellent place for the application of the techniques of statistical design of experiments. The use of these designs in corrosion research can result in more information being gained for a given expenditure of effort or money. This paper discusses the use of factorial designs and fractional replicates. Examples are taken from the field of corrosion testing of electrodeposits.

Abstract No. 63

Comparison of Salt Spray Corrosion Rates for Tin Plated Copper in Different Locations

M. S. Frant, Research Div., AMP Inc., Harrisburg, Pa.

Evidence is accumulating that the salt spray test as defined at present may vary significantly from one part of the country to another. Using a new and apparently reproducible chemical evaluation technique, the corrosion of Sn-plated Cu in different locations is reported as a function of exposure time. Results indicate that the present salt spray specifications do not include all of the variables.

Abstract No. 64

The Performance of Supplementary Chromate Films on Zinc

F. R. Nagley, Dept. of the Navy, Bureau of Ships, Washington 25, D. C., and **K. L. Procter** and **H. L. Katz,** Industrial Test Lab., Naval Shipyard, Philadelphia, Pa.

Ten commercial chromate treatments for Zn plating on steel were evaluated for comparative deterioration resistance in marine environments. Depletion rate of hexavalent Cr and contribution of trivalent Cr to the corrosion inhibiting properties of the films were studied. Determination of hexavalent Cr content and resistance to salt spray were indicated to be suitable as quality control methods. The value of chromate films is depreciated by Zn plating in thickness of 0.0002 in. and less.

Abstract No. 65

ELECTRODEPOSITION

Filamentary Growths on Copper Cathodes

T. C. J. Ovenston, C. A. Parker, and **A. E. Robinson,** Admiralty Materials Laboratory, Holton Heath, Poole, Dorset, England.

An investigation has been made of the filamentary growths, originally described by Gollop, which are produced under certain conditions during Cu plating at low current density. The conditions under which these growths occur have now been defined more clearly and the effect of various types of surface active agents in enhancing or preventing their occurrence has been demonstrated. Possible mechanisms for the formation of the filaments have been discussed.

Abstract No. 66

Microstructure of Copper Electrodeposited on Copper

T. H. Orem, U. S. Dept. of Commerce, National Bureau of Standards, Washington 25, D. C.

Investigation of the microstructure of Cu electrodeposited on Cu has disclosed the following: when the affected surface parallels (110), the electrodeposit and basis metal have identical atomic configurations; when parallel to (111), the configuration of the electrodeposit is both the same as that of the basis metal and as a twin to the close-packed surface plane; when parallel to (001), the electrodeposit is both parallel and twinned with respect to the basis metal.

Abstract No. 67

Electron Microscope Studies on Copper Electrodes in Copper Plating Baths

Shinzo Okada and **Saburo Magari,** Engineering Research Institute, Kyoto University, Kyoto, Japan

In the absence of an addition agent in a sulfate bath, facets parallel to the {210} planes of the base crystal develop on the cathode, and the {210} planes of the single Cu crystal develop on the anode. In the presence of thiourea, deposits are smoother. Thiourea has a deep influence on the microstructure of the single copper crystal anode and the {100} planes develop.

The effect of current density on the surface of each electrode obtained in a cyanide bath is strong, and the surface is smooth and has no characteristic orientation. The crystal structure of the electrode has an influence on the pattern obtained.

Abstract No. 68

The Structure of Electrodeposited Nickel

B. C. Banerjee and **A. Goswami,** National Chemical Lab., Poona-8, India

An electron diffraction study was made on the crystal structure, orientation, and mode of growth of Ni deposits from sulfate-chloride-boric acid and chloride-boric acid baths

under various bath conditions. The effect of pH, temperature, concentration, current density, mechanical stirring, etc., and of additions such as hydrogen peroxide, nickel nitrate, and sodium chloride was investigated on polycrystalline substrates. Depending on bath conditions, various preferred orientations (one-degree), mixed or otherwise, were developed and their causes have been discussed in detail. These have also been correlated with the mode of cathodic crystal growth process.

Abstract No. 69

Effect of Magnesium Sulfate on Nickel Plating Baths

Ahmad Geneidy (present address: Cairo University, Cairo, Egypt), **W. A. Koehler,** Dept. of Chemical Engrg., West Virginia University, Morgantown, W. Va., and **Willi Machu,** Dept. of Chemical Engrg., Cairo University, Cairo, Egypt

Magnesium salts have been used as constituents of Ni plating solutions over a period of many years. A careful investigation has been made to determine as far as possible the function of Mg salts in Ni plating solutions and their effect on the electrodeposits. It was found that the addition of Mg salts lowers slightly the deposition and decomposition potentials and cathodic polarization and increases the slope of the cathode potential vs. current density curves. The effect of Mg salts on the structure of the electrodeposited Ni, microscopic, x-ray diffraction, and spectrochemical studies are presented. The effects of Mg salts on cathodic current efficiency, throwing power, mechanical properties, and porosity of the deposit were investigated.

Abstract No. 70

Electroplating of Titanium and Other Polyvalent Metals from Molten Salt Electrolyte

R. S. Dean, W. W. Gullett, and **F. X. McCawley,** Chicago Development Corp., 5810 47th Ave., Riverdale, Md.

Ductile and protective plates of metals of groups IV B, V B, and VI

B have been electroplated successfully on ferrous and nonferrous metals in molten electrolytes of the halides of the plated metal and alkali or alkaline earth halides. Electrolytes and mechanism of plating formation are discussed.

Abstract No. 71

The Electrolytic Preparation of Titanium from Fused Salts, I. Preliminary Electrolytic Studies with Diaphragmed Cells

M. B. Alpert, F. J. Schultz, and **W. F. Sullivan,** National Lead Co., Titanium Div., Research Lab., P. O. Box 58, South Amboy, N. J.

Reduced titanium chlorides dissolved in fused alkali and alkaline earth chlorides may be electrolyzed in diaphragmed cells under an inert gas atmosphere to yield ductile titanium as adherent, crystalline deposits. The reduced titanium chlorides are prepared *in situ* by adding $TiCl_4$ through a hollow cathode at a controlled feed to current ratio.

Abstract No. 72

An Evaluation of Some Factors Involved in the Mechanical Testing of Electrodeposits

T. J. Whalen and **H. J. Read,** Dept. of Metallurgy, College of Mineral Industries, Pennsylvania State University, University Park, Pa.

In an evaluation of some of the factors which must be considered in the preparation of specimens for the determination of the strength and ductility of electrodeposits, and in the execution of the tests by the hydraulic-bulge technique, it was found that the nature of the basis metal, both as to composition and metallurgical condition, was relatively unimportant. It makes comparatively little difference in tensile strength whether the deposit is tested in adhesive contact with the basis metal or in the detached state, providing that the deposit thickness and the basis metal thickness are about the same. The strain rate is unimportant, but hydrogen in the deposits may affect the results considerably.

Abstract No. 73

Some Testing Cells for the Study of Electroplating Devices

J. K. Skwirzynski and **M. Huttly**, Marconi's Wireless Telegraph Co., Ltd., Baddow Res. Labs., West Hanningfield Rd., Great Baddow, Chelmsford, Essex, England

The complete theoretical treatment is given for two kinds of cells, both of which are shown to yield a reasonably linear current density distribution along the cathode. The actual value of the current densities can be ascertained directly from the total current fed into the cell. The first cell is very similar to that proposed by Hull, i.e., trapezoidal in shape, the angle of the slanting side being 45°. The electrodes can be placed either along the parallel sides of the cell or, as first suggested by Hull, along the other two sides, when a singularity of the current density appears on the slanting electrode. In both cases the current density may be arranged to be very nearly linear over almost two thirds of the length of the cathode.

The second cell is triangular in shape; the cathode is placed along the base of a 45° isosceles triangle, whereas the anode occupies a part of one of the other sides. The current density distribution along the cathode has almost a triangular shape with good linearity.

Abstract No. 74

Electrolytic Metal Powders—Production and Applications

K. H. Roll, Metal Powder Association, 130 W. 42 St., New York 36, N. Y.

Current production, imports, and production capacities for electrolytic iron powders and electrolytic copper powders are discussed as well as applications and quantities of powder used. A brief description of other methods of producing metal powders and comparative characteristics are given.

Abstract No. 75

Electrodeposition of Powders for Powder Metallurgy

C. L. Mantell, Dept. of Chemical Engrg., Newark College of Engineering, Newark, N. J.

A large number of articles are made by powder metallurgical methods from electrolytically reduced powders. In powder production, cathode current densities are much higher than those of refining; loosely adherent deposits are produced. These are dried, surface oxides removed and classified by screening. Important electrolytic powders are those of Cu, Fe, Ni, Zn, some alloys, as well as duplexes. Operating details are reviewed.

Abstract No. 76

Electrolytic Iron Powders—Production and Properties

W. M. Shafer, Plastic Metals Div., National-U. S. Radiator Corp., Johnstown, Pa.

Electrolytic iron powder is produced commercially today by one United States and several foreign firms. The powder is produced by grinding and annealing brittle cathode deposits obtained usually from iron sulfate baths. The high purity and softness of this powder make it possible to fabricate powder metallurgy parts from it superior in properties to parts fabricated from less pure nonelectrolytic iron powder. A few applications are found in the chemical, pharmaceutical, and electronic fields.

Abstract No. 77

Electrolytic Iron Powder from a Caustic Bath

Adrien Le Duc, Diamond Alkali Co., P. O. Box 348, Painesville, Ohio, and **Luther Vaaler,** Battelle Memorial Institute, Columbus 1, Ohio

Conditions for electrodepositing iron powder from a slurry of iron III oxide in caustic solution were investigated. A ductile, dendritic deposit was obtained that could be ground up easily. The size of the dendrites was greatly influenced by conditions of deposition. Particle size distribution, particle shape, ductility, flowability, purity, and compactability of several powders were examined. Tensile strength and elongation of sintered compacts were also studied.

Abstract No. 78

Electrolytic Copper Powder—Production and Properties

E. J. Clugston and **Frank Wills**, American Metal Co., Ltd., 400 Middlesex Ave., Carteret, N. J.

The effects of electrochemical and mechanical variables on the physical characteristics of electrodeposited copper powder are reviewed. A description of the operation, equipment, and quality control facilities for the commercial production of electrolytic copper powder at the U. S. Metals Refining Co. is presented. In addition, the supporting research facilities are also described.

ELECTRO-ORGANIC

Abstract No. 79

Glow-Discharge Electrolysis in Aqueous Solutions

A. R. Denaro and **A. Hickling**, Dept. of Physical Chemistry, University of Liverpool, Liverpool, England

An investigation has been carried out of the reactions occurring when an electric discharge is passed from a positive electrode to the surface of an aqueous electrolyte containing oxidizable substrates such as ferrous, azide, ferrocyanide, and cerous ions. Electrolysis is accompanied by oxidation arising from the break-up of water molecules due to the bombardment of the solution by gaseous ions, and the chemical phenomena are analogous to the effects produced by ionizing radiations. An attempt has been made to develop a general mechanism of the process which will account quantitatively for the oxidation yields and their dependence on experimental conditions.

Abstract No. 80

Electrolytic Reduction of Cyanamide II. Nature of the Reduction of Cyanamide and Formamidine

Keijiro Odo, Eiichi Ichikawa, Katsujiro Shimogai, and **Kiichiro Sugino**, Tokyo Institute of Technology, Ookayama, Meguro-ku, Tokyo, Japan

Reduction of cyanamide to formamidine seemed to be of a catalytic nature; it took place smoothly at Pd black, Sn, or Cu rather than Pb or Hg. The fact that no wave of cyanamide was detected polarographically, although it was reduced macro-electrolytically, accounted for this observation. On the other hand, the reduction of formamidine might be electrochemical and could be made to proceed well at cathodes having high H overvoltage. In the latter, Hg gave very different products from those at other cathodes.

Abstract No. 81

Electrolytic Reduction of Organic Compounds, VII. Furfural

D. D. Staker and **C. L. Wilson,** Hudson Foam Plastics Corp., Lake Ave. and Saw Mill River Rd., Yonkers, N. Y.

Albert and Lowy reduced furfural at a Pb cathode in a medium of pH 4.5-6.5 and obtained furfuryl alcohol, the two stereoisomeric pinacols, and a resinous material which was not characterized. They showed that the resinous material was produced by the cathodic process and not by purely chemical changes occurring at the same time.

This work has been repeated and extended and an emphasis has been placed on the determination of the composition of the components of the resin. It seems to consist essentially of dimeric, trimeric, and tetrameric molecules. The dimeric component is isomeric with the pinacol, has the furan rings linked in the 2- and/or 5-positions, but does not possess hydroxyl groups on adjacent carbon atoms. The more complex components seem to have furan rings linked in a similar way and to have one hydroxyl group to each furan ring, but a large proportion of the material has hydroxyl groups on adjacent carbon atoms. The evidence obtained supports the view that the resinous products are formed as the result of 1,6-reduction of furfural.

Abstract No. 82

Electrolytic Reduction of Organic Compounds, VIII. Acetone

G. W. Mansel and **C. L. Wilson,** Hudson Foam Plastics Corp., Lake

Ave. and Saw Mill River Rd., Yonkers, N. Y.

The reduction of acetone in alkaline solution has been extended with special reference to the effect of cation (Na, K, and NMe_4), concentration of acetone and electrolyte, temperature, current density, and effect of high speed rotation of the cathode. Most of the work was carried out using an amalgamated Cu cathode. Pinacol was determined by periodate titration. Current efficiencies were always over 90%. Reduction was carried out to not more than 15% and the products were entirely pinacol and alcohol.

Improvement in the yield of pinacol results from increased acetone concentration and lowered temperature in electrolytes. Increasing current density increases pinacol with KOH, leaves it essentially unchanged with NaOH, and decreases it with NMe_4OH.

Rotation of the cathode increases the yield of pinacol but only at low temperatures and low acetone concentrations. Under these conditions the following figures have been obtained:

	NaOH	KOH	NMe_4OH
Stationary Cu/Hg	26	36	46
Rotating Cu/Hg	35	44	53
Stationary Hg	6	30	53% pinacol

Abstract No. 83

An Electrolytic Study of the Course of the Clemmensen Reduction

R. A. Strehlow (present address: Oak Ridge National Lab., Oak Ridge, Tenn.) and **Sherlock Swann, Jr.**, University of Illinois, Urbana, Ill.

The electroreduction of 2-pentanone to n-pentane was carried out at a series of cathodes in the zinc-mercury alloy system. Yields of the hydrocarbon showed a distinct relation to the phase diagram of the alloy system when they were considered as functions of the cathode composition. Although amalgamated zinc is generally used as part of the reducing couple in the Clemmensen reduction of ketones to hydrocarbons, it was found that a zinc cathode

afforded the best yield of hydrocarbon in the electrolytic reduction.

Abstract No. 84

Application of Electrodialysis to Halide Interconversion in Quarternary Salts

M. J. Allen and **J. Ocampo,** CIBA Pharmaceutical Products, Inc., Summit, N. J.

In many instances it is difficult to prepare directly a quaternary salt having the desired halide component by interaction of the amine and the alkyl or aryl halide. This is especially so in cases where the chloride salt is required. Therefore, the amine must first be reacted with an iodo or bromo quaternizing agent and then exchanged for the chlorine by chemical means. This exchange has been found to be accomplished more readily by electrodialysis of the quaternary salt, followed by addition of halogen to the catholyte with subsequent isolation of the new quaternary salt. In general with this technique it is possible to exchange any halide for another or prepare non-halogen-type salts.

Abstract No. 85

Electrochemical Reduction of the C_4 Dibasic Acids and Their Esters: Acetylenedicarboxylic, Dibromomaleic, and Dibromofumaric.

Nature of the Products and Reaction Mechanisms

P. J. Elving, Dept. of Chemistry, University of Michigan, Ann Arbor, Mich., **Isadore Rosenthal,** Rohm and Haas Co., 5000 Richmond St., Philadelphia, Pa., and **J. R. Hayes** and **A. J. Martin,** Pennsylvania State University, University Park, Pa.

Acetylenedicarboxylic acid (ADCA), dibromomaleic acid (DBMA), and dibromofumaric acid (DBFA) have been reduced over a range of *p*H at a micro mercury dropping electrode, and at a massive stirred mercury cathode; coulometric measurements were made using the massive electrode. Reduction products were identified polarographically, and by isolation. DBFA and DBMA are quantitatively reduced to

ADCA in a two-electron process. Between pH 0.4 and 3.0 ADCA is reduced in a three-electron process to form racemic-α, α'-dimethylsuccinic acid; the decarboxylation and dimerization process is explained by a free radical mechanism. The esters of the three acids react similarly, except for the diethyl ester of ADCA which is reduced to diethyl fumarate. The pH-dependency of half-wave potential values in acidic solution is discussed.

Abstract No. 86

Solid Electrode Voltammetry of Organic Compounds

Theodore Kuwana, T. R. Mueller, and **R. N. Adams,** Dept. of Chemistry, University of Kansas, Lawrence, Kans.

Solid electrode voltammetry has long remained a neglected area in polarographic research. Voltammetry at controlled current is especially adaptable to solid electrode systems. The application of two controlled current techniques to anodic oxidations at Pt electrodes is discussed. Both of these methods, current-scanning polarography and chronopotentiometry, yield valuable physicochemical information on organic molecules in addition to providing rapid and precise analysis. In many cases, this data cannot be obtained by conventional polarographic methods.

Abstract No. 87

Electrochemical Studies in Cyclic Carbonate Esters

C. W. Tobias, Dept. of Chemistry and Chemical Engrg., University of California, Berkeley 4, Calif.

Solubility and conductivity studies of solutions of inorganic salts in propylene carbonate, ethylene carbonate, and γ-butyrolactone show that these solvents, although not displaying great solvent power, possess many of the properties desirable for an easily handled nonaqueous ionizing medium. Electrodeposition trials indicate the range of metals which may be deposited in these media.

Abstract No. 88

Polarographic Studies in Dimethylformamide, IV. Behavior of Aldehydes and Ketones

S. Wawzonek and **A. A. Gundersen**, Dept. of Chemistry, State University of Iowa, Iowa City, Iowa

The polarographic behavior of benzophenone, acetophenone, and benzaldehyde has been studied in anhydrous dimethylformamide as a solvent with tetrabutylammonium iodide as the supporting electrolyte. Benzophenone gave two waves which indicated a stepwise reduction to benzohydrol. Large scale electrolysis confirmed this mechanism. The formation of the intermediate ketyl was demonstrated by the products isolated when the electrolysis was carried out in the presence of carbon dioxide and ethyl iodide. The former gave benzilic acid and the latter diphenylethylcarbinol.

Acetophenone, which gave one polarographic wave, formed acetophenone pinacol when electrolyzed on a large scale. The intermediate ketyl apparently is unstable since only small amounts of atrolactic acid were formed in a large scale electrolysis in the presence of carbon dioxide. Benzaldehyde when reduced in a similar manner gave a poor yield of hydrobenzoin.

Abstract No. 89

Polarographic Reduction of Some Acetylenic Linkages

A. H. Gropp and **J. C. Ramsey, Jr.**, Dept. of Chemistry, University of Florida, Gainesville, Fla.

Two series of unsaturated quaternary ammonium salts were prepared, each compound containing an acetylenic linkage. In one series the unsaturated group was held constant and the saturated groups varied; in the other series the saturated groups were held constant and the unsaturated group lengthened. It was found that increasing the size of the saturated groups lowered the polarographic reduction potential, while lengthening the unsaturated group increased the reduction potential.

Abstract No. 90

Polarographic Reduction of Some Nitrofluorenones

Julia Gary, R. M. Powers, and **R. A. Day, Jr.,** Dept of Chemistry, Emory University, Emory University, Ga.

The polarographic reduction of 2-nitro, 2,5-dinitro, and 2,7-dinitrofluorenone has been studied in acetone-water media at various *p*H values. Attempts to interpret the reactions responsible for the various waves are reported. Coulometric measurements of the number of electrons consumed in different stages of reduction have been made. Evidence regarding the stability of the 9-fluoryl free radical is discussed.

Abstract No. 91

Electrochemical Reduction of Some Nitramines and Nitrosamines, I. Polarographic Behavior of Some Alkyl and Aryl Nitrosamines

G. C. Whitnack, R. D. Weaver, and **H. W. Kruse,** Chemistry Div., Research Dept., U. S. Naval Ordnance Test Station, China Lake, Calif.

The general behavior of dimethyl-, diethyl-, dipropyl-, diisopropyl-, and diphenylnitrosamine was investigated at the dropping mercury electrode. The effect of *p*H on the reduction process was studied in well-buffered media. Well-defined waves were produced for all the nitrosamines in 20% ethyl alcohol solutions of both mineral and organic acids. Presence of the dialkylhydrazines as the main reduction products was demonstrated by large-scale electrolysis.

Abstract No. 92

A Polarographic Study of Sodium-Iodomethane Sulfonate in Various Media

M. J. Allen and **V. J. Powell,** Research Dept., CIBA Pharmaceutical Products, Inc., Summit N. J.

Studies were performed using three different media: *p*H 3.6 and 9.18, Clark and Lubs buffers, and 0.1*N* KNO_3. Concentrations of so-

dium-iodomethane sulfonate varied from 0.5×10^{-3} to 3.5×10^{-3}M. In all media there was a linear correlation between id and concentration. In the buffered media there was an apparent one-electron change indicative of the following reaction:

$$2\,I\,CH_2SO_3^- + 2e + 2H \rightarrow CH_2SO_3^- + 2\,HI$$

$$CH_2SO_3^-$$

In the neutral medium (0.1*N* KNO_3) at the lower concentration the molecule appeared to undergo a one-electron change. As the concentration of depolarizer increased the reaction approached a two-electron change which indicated the formation of methane sulfonate:

$$I\,CH_2SO_3^- + 2e + 2H \rightarrow CH_3SO_3^- + HI$$

Abstract No. 93

Polarographic Behavior of Iodinated X-Ray Contrast Agents

Peter Kabasakalian, Schering Corp., Bloomfield, N. J.

Ten iodine-containing x-ray contrast compounds have been studied polarographically in 50% aqueous ethanol solutions at various *p*H values between 1.3 and 10.5. Both the qualitative behavior (change in wave form and positions with *p*H) and the quantitative behavior (change in wave magnitude with changes in sample concentration and temperature) of these compounds have been determined. Some macro scale electrolyses have been carried out at a mercury pool electrode to establish the degradation order of a few of these compounds.

Abstract No. 94

Polarography of Organo Tin Halides

C. M. Wheeler, Jr., Dept. of Chemistry, University of New Hampshire, Durham, N. H.

The polarographic characteristics of phenyl and alkyl substituted tin halides are presented. A well-defined reduction wave for tin is observed when organo-tin halides are reduced

polarographically in dimethylformamide solvent. Increased phenyl substitution shifts the half-wave potential to a more negative value. Short chain alkyl substitution renders the tin more difficult to reduce than does similar phenyl substitution. The particular halide anion used contributes a small but significant effect on the half-wave potential.

Abstract No. 95

Polarographic Behavior of Steroids

Peter Kabasakalian, Schering Corp., Bloomfield, N. J.

The polarographic reduction waves of several $\Delta^{1,4}$-3-ketosteroids and Δ^{4}-3-ketosteroids have been studied at various pH values in 50% ethanol-water solutions buffered with organic buffers. Changes in magnitude and position of the wave as effected by changes in pH, concentration of steroid, temperature, and mercury pressure are recorded and discussed. A possible electrode reaction mechanism has been proposed on the basis of results obtained from wave analyses and diffusion coefficient determinations. Preliminary studies of controlled potential electrolysis products support the proposed mechanism.

Abstract No. 96

Correlation of Polarographic Half-Wave Potentials with Nuclear Magnetic Resonance 'Chemical Shifts'

C. E. Bennett, (present address: Polychemicals Dept., E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.) Aeronautical Research Lab., Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, and **P. J. Elving,** Dept. of Chemistry, University of Michigan, Ann Arbor, Mich.

The extent to which polarographic half-wave potentials of organic compounds can be correlated with nuclear magnetic resonance "chemical shifts" is discussed. A linear relationship between the two parameters was obtained for formaldehyde, acetaldehyde and propionaldehyde, and for meta- and parasubstituted benzaldehydes, iodobenzenes, and nitro-

benzenes. Nonlinear results were obtained for ortho-substituted compounds and for a variety of reducible aliphatic compounds. These data support the generally accepted view that changes in half-wave potentials with structure are due both to electronic and steric effects.

Abstract No. 97

Correlation of Polarographic Half-Wave Potentials of Organic Compounds

P. J. Elving, Dept. of Chemistry, University of Michigan, Ann Arbor, Mich., and **C. E. Bennett** (present address: Polychemicals Dept., E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.) Aeronautical Research Lab., Wright Air Development Center, Wright-Patterson Air Force Base, Ohio

A generalization for correlating polarographic half-wave potentials of organic compounds with both structural and environmental factors is proposed. In a given type of molecule, the reduction of an electroactive group is facilitated as the electron density is decreased about the atom which will be attacked by an electron or electrons from the cathode. This decrease in electron density may be accomplished by many factors, e.g., substitution, orientation (adsorption) of the molecule at the electrode, pH, solvent, background electrolyte, etc. The validity of this concept is examined in respect to several representative factors including a discussion of the significance of half-wave potentials for irreversible processes. Previous correlations of half-wave potential with other experimental and theoretical approaches are reviewed.

ELECTROTHERMICS AND METALLURGY

Abstract No. 98

Equilibria between Titanium Metal and Solutions of Titanium Dichloride in Fused Sodium Chloride

K. Komarek and **P. Herasymenko,** Metallurgical Engrg., Research

Div., New York University, New York 53, N. Y.

Thermal analyses of $TiCl_3$ and NaCl in closed Ti metal crucibles were made in the range from 0 to 100 wt % $TiCl_2$. The titanium chloride present in the salt mixtures was practically all in the divalent form. The melting point of $TiCl_2$ was confirmed to be 1025°C. The phase diagram of the system $NaCl \cdot TiCl_3$ has two compounds and one eutectic. The eutectic point lies at about 50.0 wt % $TiCl_2$ and 605°C. One compound with the tentative formula $NaCl \cdot TiCl_2$ is formed by a peritectic reaction at 628°C, the other one—2 $NaCl \cdot TiCl_3$—decomposes in the solid state at 548°C.

Abstract No. 99

Reaction Kinetics of the Nitriding of Titanium Dioxide

D. L. Douglass, J. H. Borden, and **G. R. St. Pierre,** Dept. of Metallurgical Engrg., The Ohio State University, Columbus, Ohio

A study of the separation of Ti from ilmenite by the selective formation of TiN was initiated by reacting NH_3 with TiO_2 (unit activity of TiO_2) at 900°C. After an initial transition period of ½ hr, during which the reaction rate increased, $TiN_{0.42}$ formed by a pseudo first-order reaction. Upon complete disappearance of TiO_2, nitrogen was absorbed into the $TiN_{0.42}$ lattice until $TiN_{0.80}$ existed after 20 hr. $TiN_{1.0}$ was obtained within 20 hr at 1000°C. A tentative reaction mechanism is proposed.

Abstract No. 100

Continuous Electrolytic Process for the Production of High Purity Beryllium Metal

S. J. Morana, The Beryllium Corp., Reading, Pa.

An improved, continuous electrolytic process for the production of high purity beryllium metal using a low temperature fused salt bath consisting of beryllium chloride and sodium chloride is described. The evolutionary steps involved are summarized. The continuous electrolysis unit consists of several cells in a common electrolyte. Improvements

for removal of electrolyte from metal dendrites, lining the cathodes to improve purity, acid treating the final product, etc., are given.

Abstract No. 101

Equilibrium Reduction of Tungsten Oxides by Hydrogen

R. C. Griffis, Refractory Metals Lab., General Electric Co., Cleveland 17, Ohio

A study has been made on the heterogeneous equilibrium involving H_2-W-WO_2-H_2O, in the temperature interval 500°-1000°C. The apparatus constructed for equilibrium experiments and the method of synthesis of all the pure oxide phases of samples and x-ray standards are described in detail. The equilibrium data for this system have been treated by "Sigma" functions to obtain $\Delta F°$ and $\Delta H°$, for the formation of WO_2 from the elements, as a function of temperature. Difficulties arising during the study of the higher oxide systems is discussed.

Abstract No. 102

A Review of the Uses and Markets for Ferroalloys

R. W. Hale, Industrial Economics Div., Battelle Memorial Institute, Columbus 1, Ohio

A brief discussion is given concerning the structure of the industry, production and consumption of ferroalloys, uses of ferroalloys, trends in these uses, and the future growth of the industry. Sources of raw materials and such influencing factors as transportation, power availability, and location of markets are considered.

Abstract No. 103

Metallurgical Design of Submerged Arc Furnaces

W. M. Kelly, Electro Metallurgical Co., P. O. Box 580, Niagara Falls, N. Y.

Design of submerged arc furnaces has been largely a matter of electrical circuit design and arbitrary electrode arrangements without sufficient regard to metallurgical requirements. The present paper attempts to provide a basis for designing into the

furnace the necessary electrical and dimensional relationships for good metallurgical results on specific smelting applications.

Basic electrical conditions for the major ferroalloy products are presented as a design foundation. Subsequent dimensional relations involving electrode size and spacing, reaction zone sizes, and furnace shell depth and diameter are discussed. Dimensional relations when comparing packet type vs. round type of submerged arc furnaces are included.

Abstract No. 104

Electric Smelting of Low Grade Nickel Ores

L. H. Banning, Bureau of Mines, U. S. Dept. of the Interior, Albany, Oreg.

During the past several years, the U. S. Bureau of Mines has conducted electric smelting investigations on several oxidized low grade nickel ores at its Northwest Electrodevelopment Experiment Station, at Albany, Oreg. The tests have been made on ores from Riddle and Gold Beach, Oreg., Cle Elum, Wash., and on foreign ores from Brazil, Cuba, and the Philippine Islands. The ores contain from 0.7 to 4.4% Ni. Low carbon ferronickel products containing from 2.3 to 50% Ni were produced. Results of these tests are summarized and evaluated. The smelting method and uses for the ferronickel product are discussed.

Abstract No. 105

Dissociation and Electrical Conductivity of Molten Silicates

Axel Wejnarth, 97 Hamilton Blvd., Kenmore 17, N. Y.

The electronic conductivity in silicates, when measuring their combined electronic and electrolytic conductivity, is eliminated when measuring the capacitance of the silicates in correlation to existing electrolytic polarization. A large polarization capacity in the measuring equipment makes a direct proportionate measurement of existing dissociation possible.

Abstract No. 106

Ferroalloys from Low Grade Ores by the Udy Processes

M. C. Udy and **M. J. Udy**, Strategic-Udy Metallurgical & Chemical Processes, Ltd., Niagara Falls, Ont.

A two-step electric arc furnace process selectively removes iron from low grade ores in a first step and then produces standard ferroalloys in a final step. A combination of furnace design, furnace operation, and slag control makes this process feasible with low grade, low cost ores. Prototype plant operation has already demonstrated production of standard grade ferromanganese from ores containing 11% Mn and 16% Fe. The process is even more attractive with higher grade ores.

Abstract No. 107

Experimental Production of Iron, Silicospiegeleisen, and Portland Cement from a Low Grade Manganiferous Iron Ore

R. A. Campbell, **G. N. Banks**, and **R. R. Rogers**, Mines Branch, Div. of Mineral Dressing and Process Metallurgy, Dept. of Mines and Technical Surveys, 552 Booth St., Ottawa, Canada

The ore, containing Fe 30%, Mn 4%, and SiO_2 50%, was treated experimentally by a two-stage smelting process in a 250 kva furnace to produce iron, silicospiegeleisen, and slag. The slag was mixed with limestone and calcined to produce a clinker which, on grinding, had the analysis and properties of portland cement. About 35 tons of ore were processed. The two smelting stages required 11 and 7 days, respectively.

Abstract No. 108

Small, Single-Phase, Dry-Top Electric Furnace for Experimental Smelting of Manganese Ores

D. D. Blue, U. S. Dept. of the Interior, Bureau of Mines, Region II, 500 Dale St., Boulder City, Nev.

As a part of its manganese program the Bureau of Mines has conducted smelting tests for the production of standard ferromanganese

from various concentrates and off-grade ore. This paper describes the various single-phase furnaces used and the furnace as finally developed and standardized against commercial practice to obtain comparative data.

Abstract No. 109

Electrodeposition of High Purity Chromium

F. E. Block, P. C. Good, and **G. Asai,** Bureau of Mines, U. S. Dept. of the Interior, Albany, Oreg.

Thick Cr deposits were prepared by the electrolysis of aqueous chromic acid baths. Metal containing 0.005% oxygen, less than 0.002% nitrogen, and only traces of metallic impurities was obtained on electrolysis of purified solutions at elevated temperatures. After consumable electrode arc-melting, Cr could be hot worked to rod and drawn to wire which was ductile at room temperature.

SPRING MEETING
at the
STATLER HOTEL
New York, N. Y.
April 27, 28, 29, 30, and May 1, 1958

Sessions probably will be scheduled on

Electric Insulation
Electronics (including Luminescence, Semiconductors, Oxide Cathodes, Instrumentation, and possibly Screen Applications)
Electrothermics and Metallurgy
Industrial Electrolytics
Theoretical Electrochemistry

Abstracts for the Spring Meeting *(not exceeding 75 words in length)* must reach the Secretary's Office, 1860 Broadway, New York 23, N. Y. *not later than January 2, 1958* in order to be included in the program.

Indicate on abstract for which Division's symposium the paper is to be scheduled.

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